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UNIVERSITY OF CALIFORNIA PUBLICATIONS

ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 344

A STUDY OF STARS WITH LARGE PROPER MOTIONS

I

A CATALOGUE OF STARS WITH PROPER MOTIONS EXCEEDING 0".50 ANNUALLY

INTRODUCTION

The large number of proper motions published in recent years makes it desirable to prepare a new list of stars with proper motions exceeding 0".50 annually. This catalogue may serve as preliminary evidence regarding the distribution of stars in space, as long as our knowledge of parallaxes is so limited, and may be useful as a list from which parallax observers, especially in the southern hemisphere, can select stars for their observing programme.

The most recent list of such stars was published by van Maanen[1] in 1915 and revised and extended by him in 1916[2].

But since then, the more accurate, recently-determined proper motions have made a revision desirable. For besides the twenty proper motions mentioned in van Maanen's revised list as falling below 0".50, fifty additional stars, the proper motions of which are less than 0".50 according to Boss or Porter[3], should also be excluded.

All the material available at the Lick Observatory in April, 1922, has been used in preparing the present list. For the brighter stars, the proper motions have been taken from Boss's *Preliminary General Catalogue* whenever possible; for the fainter stars preference was given to Porter's *Catalogue* (*loc. cit.*) except in a few cases where his proper motions rest on a small number of observations. The stars not included in either of these lists usually have but one determination of proper motion. Because many of the proper motions are announced only to hundredths of a second of arc, those given to thousandths have been included here, when their values equal or exceed 0".495. It should be mentioned that the list published in *Union Observatory Circulars*, No. 19, according to Innes himself, includes many doubtful cases, in need of confirmation.

The different columns of the catalogue may be described as below.

No. and H.D. give the current number in the present catalogue and the number in the new *Henry Draper Catalogue*. An asterisk in the first column refers to remarks at the end of the list.

The third column gives the names of the stars, assigned according to the following system: First are used the Bayer letters or the Flamsteed, Hevelius and Gould numbers, following the nomenclature of Ambronn's *Sternverzeichnis*. Reference is given next to the Catalogues of the Astronomische Gesellschaft, as far as published, and otherwise to the *Cordoba General Catalogue*. In this case the name *Cordoba* is printed in full, whereas the *Cordoba Gesellschaft Catalogues* are referred to as *Cord A* and *Cord B* (−22° to −32°). For stars not contained in any of these catalogues the B.D. or C.P.D. numbers are used, and for the still fainter stars the number in the *Carte-du-Ciel* zones or in Wolf's list.[4]

The system employed here has the slight disadvantage that such well-known stars as *Lalande* 21258 and *Groombridge* 1830 are called by their *A. G.* names, but the old names can almost be regarded as proper names, like *Sirius*, and are therefore given in the remarks. On the other hand, the present nomenclature is systematic and avoids the calling of one star by two names, as is the case with *Groombridge* 34 = *Lalande* 248 and *Lalande* 21185 = 22 H *Camelopardalis.* It also reduces considerably the number of catalogues and does not demand a knowledge of the abbreviations used for the older catalogues. The system proposed here is given as a tentative one only, as it is hoped that the International Astronomical Union will make a decision in this case.

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[1] *Contributions Mt. Wilson Obs.*, No. 96. *Ap. Jour.*, **41**, 187, 1915.

[2] *Contributions Mt. Wilson Obs.*, No. 111.

[3] *Publ. Cincinnati Obs.*, **18**, Pt. IV.

[4] *Veröff. Bad. Sternw. Heid.*, **7**, No. 10.

The columns Mag. and Sp. give the visual magnitude and spectrum, both taken from the *Henry Draper Catalogue,* as far as possible. (I am greatly indebted to Dr. Harlow Shapley for his kindness in supplying me with the unpublished H.D. data for the stars between R.A. 17^h and 24^h.) For some of the fainter stars, *Contributions Mt. Wilson Obs.*, Nos. 96 and 199, were consulted, and for a few Wolf-stars the spectra were determined by myself at the Lick Observatory. Details for the latter stars will be published later. These cases can be distinguished easily, as the H.D. number is then absent. For stars not in the *Henry Draper Catalogue* the magnitudes of the A.G. Catalogues were used, and, for fainter stars the B.D. and C.P.D. (photographic) magnitudes, and finally those given by the authority for the proper motion. Photographic magnitudes are denoted by italics. No attempt has been made here to reduce these magnitudes to the Harvard system, as the corrections to be applied are in many cases doubtful. Corrections have been applied, however, in computing the quantities H and M (see below), as these are used for statistical purposes. For this purpose the Tables E, H, and I in *Groningen Publications,* No. 30, were consulted. The values given there apply to the mean of all the stars considered, whereas for the present list only those stars were selected whose proper motions exceed $0''.5$ annually. Accordingly the stars considered here are of a more advanced spectral class than the mean of all and have therefore a higher positive color-index. For this reason they were supposed to be half a magnitude brighter, *visually* than the tables give, and corrections were adopted as in Table I. The first column in this table refers to the individual magnitudes and the corrections required are given in the remaining columns in the sense Harvard visual − Furuhjelm, etc.

The columns R. A. and Dec. in the catalogue give the mean positions of the stars for the equinox of 1900.

μ and p are the total annual proper motion expressed in arc of the great circle, and its direction, if possible given to $0''.001$ and $0^\circ.0$, which units correspond to the same order of accuracy for $\mu = 0''.57$. The directions for the Wolf−, Innes− and Hertzsprung stars are given as published without reduction to 1900.0. The proper motions are all tabulated as given by the authorities, without reduction to a uniform system, as this is at present not possible.

TABLE I

Mag.	Furuhjelm	Wolf	Innes
$8^m.0$	$0^m.0$		
9.0	0.0		$-0^m.3$
10.0	0.0	$+0^m.5$	0.0
11.0	0.0	0.4	+0.3
12.0		0.3	+0.1
13.0		0.2	0.0
14.0		+0.1	
15.0		0.0	
16.0		−0.1	

Source:—This column contains the reference to the source of proper-motion data. The different entries may be explained as follows:

P.G.C.—Boss's *Preliminary General Catalogue.*

Ci. 18—*Publications of the Cincinnati Observatory,* **18,** pt. IV.

U.C.—*Circulars of the Union Observatory. U.C.* 19 is a compilation of results obtained at different observatories, but, as Innes states, contains many doubtful data. The later circulars contain mostly proper motions determined by "blinking" photographic plates.

Finn. Acad.—Furuhjelm's list in *Finska Vetenskaps-Societetens Förhandlingar,* **59,** A, No. 22, 1917.

Heid.—Wolf's *Katalog von* 1053 *stärker bewegten Fixsternen* in *Veröffentlichungen der Badischen Sternwarte zu Heidelberg,* **7,** No. 10.

Gr.Astr. 4—*Greenwich Astrographic Catalogue,* Vol. 4.

In addition there are some references to current periodicals which need no further explanation.

The column H gives the quantity $m+5+5 \log \mu$, the function of the proper motion corresponding to the absolute magnitude. This was denoted by M_μ in my earlier paper.

Columns headed π and M contain the parallax and absolute magnitude. I wish to express my sincere thanks to Dr. Knut Lundmark for his kindness in inserting these parallaxes from a card catalogue compiled by him.

The last three columns give in order the radial velocities taken from Voûte's *First Catalogue of Radial Velocities* without reduction to one system, and the galactic longitude and latitude for 1900, with the galactic pole assumed to be at $\alpha = 12^h\ 42^m$, $\delta = +27^\circ.2$ (1900.0).

LIST OF STARS WHOSE ANNUAL PROPER MOTIONS ARE NOT LESS THAN 0″.50

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
1	55	CPD−68° 3597	$8^{m}7$	K0	$0^{h}\ 0^{m}16^{s}$	−68°22′.4	0″.531	205°.3	U.C. 19	$12^{m}3$				276°	−48°
2*	69	CPD−79° 1249	7.82	K0	0 23	−79 48.6	0.768	130.6	U.C. 19	12.2				272	−37
3	38	Bo 18443_1	9.3	K7	0 24	+45 15.5	0.858	98.6	Ci. 18	14.0	0.101	9.3		82	−17
4		Bo 18443_2	9.4	K8	0 24	+45 15.5	0.858	98.6	Ci. 18+Bu.	14.1	0.107	9.5		82	−17
5	142	37 *Phoenicis*	5.77	G0	1 8	−49 37.9	0.532	94.7	P.G.C.	9.4	0.004	−1.2		287	−66
6			*12.5*		1 16	−66 22.6	0.605	163.	U.C. 53	16.4				277	−51
7	432	*β Cassiopeiae*	2.42	F5	3 50	+58 35.9	0.559	108.9	P.G.C.	6.1	0.085	2.0	+12.8	85	− 4
8		Wolf 1	*13.5*		8 29	− 0 14.0	0.53	110.	Heid.	17.2				72	−62
9	1188	CPD−38° 14	9.1	K5	11 7	−38 7.1	1.000	180.0	U.C. 34	14.1				296	−77
10		BD+40° 45	9.4		11 47	+40 23.4	0.580	81.4	Finn. Acad.	13.2				84	−22
11*	1326	Bo 187	8.1	Ma	12 40	+43 27.4	2.890	82.1	Ci. 18	15.4	0.282	10.4	+ 3.	84	−20
12		Comp to Bo 187	10.7	Mb	12 43	+43 27.6	2.890	82.1	Ci. 18+Bu.	18.0	0.282	13.0		84	−20
13	1581	*ζ Toucanae*	4.34	F8	14 52	−65 27.7	2.060	55.5	P.G.C.	10.9	0.138	5.0	+ 9.2	275	−52
14		CPD−53° 77	*10.5*		18 1	−53 3.7	0.572	185.	U.C. 48	14.4				277	−62
15	2025	Cord B 118	7.8	G5	19 20	−27 35.0	0.669	84.4	Ci. 18	11.9				356	−86
16	2070	45 *Phoenicis*	6.90	G0	19 48	−51 35.5	0.592	116.1	P.G.C.	10.8				278	−65
17	2151	*β Hydri*	2.90	G0	20 30	−77 49.0	2.268	81.8	P.G.C.	9.7	0.133	3.5	+22.2	270	−40
18		BD +66° 34	9.5	Ma	26 12	+66 42.0	1.775	96.5	Gr. Astr. 4	16.0				88	+ 3
19	3074	78 *Sculptoris*	6.57	G0	28 50	−35 32.4	0.524	174.0	P.G.C.	10.2				290	−81
20	3443	82_1 *Ceti*	6.4	K0	32 13	−25 19.1	1.390	90.4	P.G.C.	12.1	0.088	6.1	+16.8	24	−87
21		82_2 *Ceti*	6.5	K0	32 13	−25 19.1	1.390	90.4	P.G.C.+Bu.	12.2	0.088	6.2	+16.8	24	−87
22*		Wolf 1056	*11.0*	A3	33 29	+30 4.1	1.69	85.	A.N. **210**, 293	17.5				88	−33
23	3628	Alb 142	7.41	G0	34 0	+ 2 34.5	0.819	68.8	Ci. 18	12.0	0.031	4.9	−29.	87	−60
24	3651	54 *Piscium*	6.08	K0	34 10	+20 42.7	0.595	229.4	P.G.C.	10.0	0.114	6.3	−33.9	87	−42
25	3765	Lund 260	7.52	K0	35 20	+39 39.4	0.797	154.4	Ci. 18	12.0	0.053	6.1	−62.	89	−21
26	3795	Cord A 306	6.24	K0	35 31	−24 20.7	0.711	117.4	Ci. 18	10.5	0.050	4.7		60	−87
27	3823	60 *Toucanae*	5.79	G0	35 44	−60 1.0	0.979	62.5	P.G.C.	10.7				271	−57
28			*10.4*		37 22	−52 53.8	0.886	246.0	U.C. 48	15.3				271	−64
29		CPD−57° 145	*11.1*		38 8	−57 29.7	0.638	180.0	U.C. 48	15.4				271	−60
30	4256	Alb 182	8.14	K0	39 57	+ 1 15.2	0.591	186.1	Ci. 18	12.0	0.059	7.0	+ 6.9	88	−62
31	4308	Cordoba 687	6.70	G5	40 24	−66 10.6	0.719	170.6	U.C. 19	11.0				270	−51
32	4614	*η Cassiopeiae* A	3.64	F8	43 3	+57 17.1	1.242	116.1	P.G.C.	9.1	0.184	4.9	+10.0	90	− 6
33		*η Cassiopeiae* B	7.41	K5	43 3	+57 17.1	1.242	116.1	P.G.C.	12.9	0.184	8.7		90	− 6
34	4628	Allb 204	5.82	G5	43 8	+ 4 46.0	1.366	146.8	P.G.C.	11.5	0.163	6.9	−11.8	91	−59
35*		v Maanen's star	12.34	F?	43 52	+ 4 55.1	3.01	155.	A.S.P. **29**, 258+Heid.	19.7	0.255	14.3		91	−59
36	4747	Cord A 389	7.22	G5	44 27	−23 45.7	0.517	76.4	Ci. 18	10.8				105	−87
37		Wolf 33	*11.2*	Ma	45 20	+57 44.9	1.58	71.1	Heid.+A.J. **29**, 168	17.6	0.064	10.6		90	− 5
38	5133	Cord B 315	7.16	G5	48 6	−30 54.1	0.631	87.5	Ci. 18	11.2				246	−86
39	5351	Chri 174	9.4	K	50 21	+68 30.5	0.763	107.2	Gr. Astr. 4	13.8				91	+ 5
40		Wolf 40	*14.*		52 16	+62 15.9	0.79	335.	Heid.	18.6				91	0
41	5802	Lpz I 259	9.00	F2	54 28	+14 4.2	0.548	274.7	Dunsink VII	12.7				95	−49
42		Wolf 44	*11.5*		55 8	+60 50.2	0.98	157.	Heid.	16.8				92	− 2
43		BD+61° 195	*10.5*	Ma	56 19	+61 48.5	0.72	82.	Heid.	15.3				92	− 1
44		Wolf 47	*13.*		56 58	+61 49.6	0.82	80.	Heid.	17.8				92	− 1
45	6434	Cordoba 992	7.80	G0	1 0 4	−40 0.6	0.586	203.0	U.C. 19	11.6				255	−77
46		Hels 914	8.7		0 19	+63 23.8	1.547	79.2	Ci. 18	14.7	0.090	8.5		92	+ 1
47	6582	*μ Cassiopeiae*	5.26	G5	1 37	+54 25.8	3.760	114.5	P.G.C.	13.2	0.148	6.1	−97.4	93	− 9
48		Wolf 56	*11.*		1 53	+62 59.1	1.08	90.	Heid.	16.6				92	0
49	6660	Be B 341	8.6	K0	2 14	+22 26.0	0.525	166.1	Ci. 18	12.2	0.110	8.8		96	−40
50	6755	Hels 956	7.8	G0	3 17	+61 0.7	0.638	85.5	Ci. 18	11.8	0.026	4.9	−325.	93	− 2
51*			13.0		6 1	−72 45.5	0.730	54.8	U.C. 19	17.3				267	−44
52	7570	*ν Phoenicis*	4.88	G0	10 40	−46 3.9	0.687	74.3	P.G.C.	9.1			+11.8	256	−71
53	7983	W Ott 266	8.9	G0	14 1	− 9 27.2	0.528	206.8	Ci. 18	12.5	0.037	6.7		115	−70
54		Lei 494	8.8	K2	15.50	+30 49.2	0.50	99.3	Ci. 18	12.3	0.032	6.3		99	−31
55	8262	Be A 387	8.0	F8	1 16 52	+18 9.5	0.524	91.5	Ci. 18	11.6	0.030	5.4	0.0	101	−44

LIST OF STARS WHOSE ANNUAL PROPER MOTIONS ARE NOT LESS THAN 0″.50—*Continued*

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
56	8553	Be A 401	9^{m}1	K0	1^{h}19^{m}27^{s}	+17°59′.0	0″.606	108°.6	Ci. 18	13″.0	0″.028	6^{m}3		102°	−44°
57	8997	Be B 448	7.9	G5	23 35	+21 12.6	0.495	112.5	Ci. 18	11.4	0.066	7.0		103	−41
58	10126	Cbr E 918	7.9	G5	33 56	+27 35.9	0.502	71.6	Ci. 18	11.4	0.056	6.5	+57.0	104	−34
59	10145	Chri 309	7.6	G5	34 11	+66 24.6	0.753	109.5	Ci. 18	12.0	0.038	5.5	+15.	96	+ 4
60	10307	41 H *Andromedae*	5.10	F8	35.42	+42 6.7	0.819	100.1	P.G.C.	9.7	0.106	5.2	+ 5.0	100	−20
61	10436	Hels 1498	8.2	K2	36 45	+63 20.1	0.70	214.4	Ci. 18	12.4	0.079	7.7		96	+ 1
62	10476	107 *Piscium*	5.32	G5	37 4	+19 46.9	0.734	203.8	P.G.C.	9.6	0.127	5.8	−34.2	106	−43
63	10520	BD−18° 287	7.4	G0	37 22	−18 23.7	0.543	90.0	Ci. 18	11.1	0.029	4.7		146	−74
64	10700	*τ Ceti*	3.65	K0	39 25	−16 27.8	1.920	296.5	P.G.C.	10.0	0.323	6.2	−16.0	144	−72
65	10780	Hels 1576	5.74	K0	40 31	+63 21.5	0.634	111.8	P.G.C.	9.7	0.107	5.9	+ 1.9	97	+ 1
66	11507	Cord A 869	8.9	K5	48 2	−22 55.7	0.857	89.5	Ci. 18	13.6				165	−75
67	11937	*χ Eridani*	3.73	G5	52 4	−52 6.4	0.734	66.8	P.G.C.	8.0			− 5.7	248	−62
68	12387	Cordoba 1990	*7.3*	Go	56 18	−41 12.2	0.58	138.9	Ci. 18	11.1				227	−70
69		Wolf 110	*11.*		57 21	+ 5 14.4	2.43	106.	Heid.	18.3	0.041	11.3 ~~2.43~~		122	−53
70			*9.9*		2 0 39	+44 43.2	0.510	149.1	Finn. Acad.	13.4				104	−16
71	12873	Cord A 976$_1$	9.5	G5	0 58	−24 51.4	0.500	119.3	U.C. 19	13.0				175	−72
72	12889	Cord A 976$_2$	9.2	G5	1 2	−24 51.2	0.500	119.3	U.C. 19	12.7				175	−72
73			*12.5*		4 24	−67 3.9	1.800	78.	U.C. 53	18.8				258	−48
74	13445	Cordoba 2201	6.28	G5	6 24	−51 18.9	2.229	72.7	Ci. 18	13.0				243	−61
75*		BD+2° 348	*10.5*	Ma	7 24	+ 3 10.4	2.60	223.	Heid.	18.1				128	−53
76	13579	Chri 392	7.8	Ko	7 32	+67 12.8	0.603	119.7	Ci. 18	11.7	0.040	5.8		98	+ 6
* 77		Wolf 125	*13.*		8 14	+15 31.4	1.08	110.	Heid.	18.4	−0.004			119	−42
78	13783	Hels 2019	8.40	G0	9 12	+64 29.8	0.50	228.7	Ci. 18	11.9	0.030	5.8		99	+ 3
79		Nic 445	8.5	F8	9 28	− 1 40.0	1.034	94.4	Ci. 18	13.6	0.018	4.8		133	−57
80		Wolf 127	*11.5*		10 2	+ 7 2.4	0.52	140.	Heid.	15.4				125	−50
81	13974	*δ Trianguli*	5.07	G0	10 57	+33 46.0	1.178	102.1	P.G.C.	10.5	0.099	5.1	− 4.	110	−26
82*		Star near W *Andr*	12.4		11 51	+43 48.6	0.5		MS. Yerkes	15.9	0.051	10.9		117	−16
83	14214	Alb 648	5.82	F8	12 50	+ 1 17.1	0.526	44.2	P.G.C.	9.4	0.037	3.6		130	−54
84		Be C 326	9.0	K2	14 2	+70 43.4	0.62	110.0	Ci. 18	13.0	0.036	6.8		97	+ 9
85	14412	22 *Fornacis*	6.38	G0	14 30	−26 25.1	0.506	332.7	P.G.C.	9.9	0.052	5.0		180	−69
86	14679	Cord B 903	9.4	G5	16 58	−30 59.8	0.594	169.2	Ci. 18+U.C. 19	13.3				197	−69
87	16160	Lpz II 961	5.92	K0	30 36	+ 6 24.6	2.320	50.7	P.G.C.	12.7	0.135	6.5	+22.5	133	−48
88		Comp to Lpz II 961	11.5	Mb	30 46	+ 6 24.6	2.320	50.7	P.G.C.+M.W.111	18.6	0.135	12.1		133	−48
89	16397	Lei 990	7.21	G0	32 35	+30 23.6	0.625	231.3	Ci. 18	11.2	0.030	4.6	−99.	116	−28
90	16784	Cord B 1044	8.1	G0	36 17	−30 34.0	0.595	82.8	Ci. 18	12.0				196	−65
91		Wolf 1132	*11.*		38 56	− 9 14.0	1.2	125.	A.N. **213**, 15	16.8				152	−57
92	17647	Bo 2435	9.2	G5	44 56	+45 34.4	0.63	124.4	Ci. 18	13.2	0.020	5.7		111	−13
93	17660	Be A 767	9.19	K5	45 2	+15 18.4	0.510	142.8	Ci. 18	12.7				129	−38
94			*10.5*		46 59	−53 33.8	0.528	345.0	U.C. 48	14.2				237	−56
95	18168	Cordoba 3111	8.6	K5	49 58	−36 18.5	0.509	108.3	U.C. 19	12.1				207	−62
96	18702	Lpz II 1123	8.2	G5	55 15	+ 5 35.6	0.667	104.5	Ci. 18	12.3	0.088	7.9	+66.7	140	−45
97	18757	Hels 2711	6.67	G0	55 58	+61 19.9	1.004	133.0	Ci. 18	11.7	0.065	5.8	−7.	105	+ 1
98		Comp to Hels 2711	12.6		56 31	+61 22.	1.13	134.5	A.S.P. **29**, 258	17.9	0.065	11.7		105	+ 1
99	18907	*ε Fornacis*	5.90	G0	57 19	−28 28.5	0.498	145.1	P.G.C.	9.4				191	−61
100	19305	Alb 886	8.9	K5	3 1 14	+ 1 36.2	0.91	158.8	Ci. 18	13.7				146	−46
101	19373	*ι Persei*	4.17	G0	1 51	+49 13.9	1.269	93.5	P.G.C.	9.7	0.107	4.4	+49.6	112	− 8
102*	19445	Cbr E 1581	8.0	F2	2 32	+25 58.2	0.861	193.6	Ci. 18	12.7	0.027	5.2	−15.3	126	−28
103			*10.2*	Ma	2 49	+45 21.6	0.516	232.5	Finn. Acad.	13.8				115	−10
104		Wolf 134	*14.*		7 35	+18 28.9	1.74	130.	Heid.	20.3	0.052	13.8		132	−32
105	20010	*α Fornacis* A	3.95	F8	7 49	−29 22.9	0.726	26.6	P.G.C.	8.3	0.082	3.6	−21.0	193	−58
106		*α Fornacis* B	6.9		7 49	−29 22.9	0.726	26.6	P.G.C.	11.2	0.082	6.5		193	−58
107	20165	Lpz II 1209	7.7	K0	9 22	+ 8 37.2	0.578	132.6	Ci. 18	11.5	0.092	7.5	−21.	140	−40
108	20766	ζ_1*Reticuli*	5.48	G0	15 36	−62 57.5	1.490	63.3	P.G.C.	11.4	0.100	5.5	+13.5	245	−47
109	20794	*e Eridani*	4.30	G5	15 56	−43 27.1	3.159	76.4	P.G.C.	11.8	0.152	5.2	+87.4	218	−56
110	20807	ζ_2*Reticuli*	5.16	G0	16 2	−62 53.3	1.489	62.1	P.G.C.	11.1	0.100	5.2	+12.2	245	−47

* van Maanen, letter 1928 Jan 13

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
111		Wolf 156	*14*^{m}		$3^h17^m52^s$	+43°38′.2	0″.52	130°.	Heid.	$17^m.7$				118°	−10°
112	21197	Strb 817	8.1	K0	20 4	− 5 41.7	0.816	197.0	Ci. 18	12.7	0.066	7.2		156	−47
113		BD+66° 268	9.2		21 48	+66 25.8	1.669	129.4	U.C. 43	15.5				105	+ 9
114	21531	BD−20 643	8.2	K5	23 19	−20 9.6	0.603	59.7	Ci. 18	12.1				178	−53
115	22001	κ*Reticuli*	4.80	F5	27 38	−63 17.4	0.519	44.7	P.G.C.	8.4			+12.1	245	−45
116	22049	ε *Eridani*	3.81	K0	28 13	− 9 47.8	0.970	270.8	P.G.C.	8.7	0.318	6.3	+15.6	163	−47
117		Wolf 194	*12.*		29 3	+41 22.3	1.06	80.	Heid.	17.4				121	−11
118	22484	10 *Tauri*	4.40	G5	31 46	+ 0 5.1	0.536	205.9	P.G.C.	8.0	0.066	3.5	+28.6	152	−42
119		Wolf 204	*11.5*		33 35	+25 9.8	0.69	149.	Heid.	16.0				132	−23
120		Wolf 205	*11.8*		33 40	+25 10.3	0.69	149.	Heid.	16.3				132	−23
121	22879	Strb 902	6.74	F8	35 17	− 3 32.1	0.745	106.9	Ci. 18	11.1	0.023	3.5	+113.7	158	−43
122		Wolf 1057	*12.5*		36 54	+12 13.9	1.44	155.	A.N. **210**, 327	18.6				147	−28
123	23249	δ *Eridani*	3.72	K0	38 27	−10 6.1	0.749	352.9	P.G.C.	8.1	0.142	4.5	− 5.4	166	−46
124		Wolf 219	*13.*		38 48	+18 8.8	1.25	155.	Heid.	18.7				137	−27
125	23456	Cordoba 4141	7.02	F8	40 11	−50 58.4	0.52	13.5	Ci. 18	10.6				228	−49
126	23439	Bo 3157	8.2	G5	40 12	+41 9.0	1.373	153.8	P.G.C.	13.9	0.040	6.2		123	−10
127		Comp to Bo 3157	8.8	K2	40 13	+41 9.0	1.373	153.8	P.G.C.	14.5	0.040	6.8		123	−10
128	23754	τ_6 *Eridani*	4.33	F8	42 33	−23 32.7	0.548	197.2	P.G.C.	8.0	0.070	3.5	+ 5.6	185	−50
129	24002	Nic 817	8.64	G5	44 24	+ 1 3.6	0.67	160.4	Ci. 18	12.7	0.026	5.7		155	−37
130		Wolf 227	*13.5*		46 57	+16 43.9	0.99	155.	Heid.	18.6				141	−28
131	24331	Cordoba 4297	8.4	K0	47 10	−42 53.1	0.62	20.8	Ci. 18	12.4				216	−50
132	24451	Kas 586	8.32	K5	48 24	+75 53.1	0.645	145.2	P.G.C.	12.3	0.067	7.4		101	+17
133	25329	Lei 1521	8.62	G5	56 32	+35 1.9	2.200	127.8	P.G.C.	15.3	0.045	6.9		129	−12
134		BD−21° 784	9.1		4 2 12	−21 6.0	0.79	171.8	Ci. 18	13.6				184	−45
135			*12.5*		6 31	−53 39.1	1.240	63.0	U.C. 48	18.0				230	−44
136*		Be B 1366	8.9	F2	8 37	+22 6.4	0.54	124.9	Ci. 18	12.6	0.010	3.9	+339.	141	−20
137	26965	o_2 *Eridani* A	4.48	G5	10 40	− 7 48.5	4.082	212.7	P.G.C.	12.6	0.198	6.0	−41.6	168	−38
138	26976	o_2 *Eridani* B	9.7	A	10 45	− 7 48.6	4.082	212.7	P.G.C.	17.8	0.198	11.2		168	−38
139		o_2 *Eridani* C	10.8	Md	10 45	− 7 48.6	4.082	212.7	P.G.C.	18.9	0.198	12.3		168	−38
140	27274	La Plata I 688	7.1	K0	13 18	−53 34.2	0.986	69.0	U.C. 48	12.1				229	−43
141		Cbr M 1885	8.6		27 52	+55 12.8	0.64	116.9	L. O. Bull. **10**, 22	12.7				118	+ 6
142		Cbr M 1893	8.5	K6	29 47	+52 42.1	0.53	149.4	Ci. 18	12.1	0.106	8.6		121	+ 4
143	29137	Cordoba 5173	7.8	G0	30 6	−68 6.1	0.495	24.7	U.C. 19	11.3				247	−37
144	29587	Bo 3772	7.29	G0	34 31	+41 56.1	0.690	127.3	Ci. 18	11.5	0.028	4.5	+101.3	130	− 4
145*	29907	CPD−65° 361	9.6	G0	37 38	−65 39.0	1.467	27.	U.C. 53	14.4				243	−37
146	306.49	Bo 3893	7.12	G0	44 22	+45 40.7	0.676	146.3	Ci. 18	11.3	0.070	6.3	+26.	128	0
147	31501	Lei 1812	8.0	G5	51 20	+34 7.0	0.60	108.4	Ci. 18	11.9	0.023	4.8		138	− 4
148	32147	W Ott 1303	6.50	K0	55 51	− 5 52.3	1.247	153.7	Ci. 18	12.0	0.121	6.9	+26.	172	−26
149	32923	104 *Tauri*	5.04	G0	5 1 32	+18 30.6	0.541	88.8	P.G.C.	8.7	0.054	3.7	+20.	152	−12
150*		BD+19° 869	*10.*		6 57	+19 37.0	0.71	150.	Heid.	14.8				151	−11
151	33725	Strb 1374	8.0	K0	7 8	− 9 13.2	0.57	185.9	Ci. 18	11.8	0.038	5.9		177	−25
152*	33793	Kapteyn's Star	9.2	K2	7 42	−44 58.8	8.764	130.5	Ci. 18	18.9	0.309	11.6	+242.	218	−35
153		BD+44°1142	*10.2*		7 43	+44 25.8	0.674	177.2	Finn. Acad.	14.3				131	+ 4
154	34411	λ *Aurigae*	4.85	G0	12 6	+40 0.6	0.843	141.0	P.G.C.	9.5	0.070	4.0	+65.4	134	+ 2
155	34673	Strb 1493	8.6	K0	14 8	− 3 10.9	0.722	78.1	Ci. 18	12.9	0.067	7.9		173	−21
156		Comp to Strb 1493	12.5		14 8	− 3 10.9	0.722	78.1	Ci. 18+Bu.	16.8	0.067	11.6		173	−21
157	36003	Strb 1574	8.6	K0	23 29	− 3 33.6	0.841	200.3	Ci. 18	13.2	0.066	7.7		174	−20
158	36395	Strb 1611	8.8	Ma	26 23	− 3 41.7	2.222	160.5	Ci. 18	15.5	0.157	9.8		174	−20
159	36443	Nic 1360	8.38	G5	26 36	+ 0 2.2	0.507	162.6	Ci. 18	11.9				171	−17
160	37008	Cbr M 2241	7.9	K0	30 24	+51 22.8	0.563	281.3	Ci. 18	11.7	0.039	5.9	−43.8	128	+11
161	37394	Cbr M 2262	6.41	K0	33 14	+53 26.4	0.510	178.8	P.G.C.	9.9	0.100	6.4	+ 1.7	126	+12
162	38014	Alb 1860	8.8	K0	37 31	+ 2 38.7	0.54	160.6	Ci. 18	12.5				170	−13
163	38230	Lund 2912	7.33	K0	39 9	+37 15.4	0.706	135.2	Ci. 18	11.5	0.088	7.0	−30.4	161	+ 4
164		Wolf 237	*12.*		39 29	+44 5.6	0.67	235.	Heid.	16.4				134	+ 8
165	39091	π*Mensae*	5.65	G5	45 8	−80 32.7	1.094	11.7	P.G.C.	10.8			+12.2	259	−28

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
166	39194	Cordoba 6886	$8^{m}34$	G0	$5^{h}45^{m}41^{s}$	−70°12′.8	1″.26	343°.9	Ci. 18	$13^{m}8$				248°	−30°
167	39364	δ *Leporis*	3.90	K0	47 1	−20 53.3	0.696	161.2	P.G.C.	8.1	0.025	0.9	+99.2	193	−20
168	39881	Lpz I 1885	6.48	G5	50 20	+13 55.3	0.629	139.9	Ci. 18	10.5	0.056	5.2	− 2.	162	− 5
169	40105	Cordoba 7009	6.50	K0	51 44	−50 23.7	0.600	0.0	U.C. 19	10.4				225	−28
170	40409	36 *Doradus*	4.53	K0	53 20	−63 7.2	0.562	13.6	P.G.C.	8.3			+25.7	240	−29
171		Wolf 261	*14.*		55 58	+47 49.1	0.75	190.	Heid.	18.5				131	+12
172	40887	Cord B 2689	8.60	K5	56 36	−31 2.7	0.543	308.8	U.C. 19	12.3				204	−23
173		Cord B 2690	8.60	K5	56 37	−31 2.8	0.543	308.8	U.C. 19	12.3				204	−23
174*		Be A 1866	9.0	F8	57 16	+19 22.7	0.93	133.3	Ci. 18	13.8	0.017	5.2	−190.	159	− 1
175		Cbr E 2935	8.9		59 42	+26 34.3	0.50	220.	Ci. 18+Heid.	12.4				152	+ 3
176			*12.5*		6 2 17	−55 19.1	0.701	243.3	U.C. 48	16.7				230	−28
177		Wolf 1058	*12.*		4 33	+25 58.1	0.64	159.	A.N. **210**, 387	16.3				152	+ 4
178	42581	BD−21° 1377	8.7	K5	6 22	−21 49.5	0.68	188.3	Ci. 18	12.9				196	−17
179		BD+47° 1276	9.5		9 12	+47 6.6	0.52	180.	Heid.	13.4				134	+14
180			*11.7*		11 2	−65 9.4	0.808	165.	U.C. 53+37	16.4				242	−28
181	45289	Cordoba 7822	6.76	G5	21 21	−42 48.8	0.75	353.2	Ci. 18	11.2				218	−21
182			*10.5*		21 43	+35 57.6	0.53	131.	A.N. **207**, 171	13.3				145	+12
183		Cbr E 3265	8.7		22 52	+27 5.0	0.50	207.3	Ci. 18	12.2				153	+ 8
184	46588	23 H *Camelopardalis*	5.60	F8	29 10	+79 40.4	0.620	186.0	P.G.C.	9.6	0.048	4.0	+12.0	103	+26
185		BD+17° 1320	9.5	Ma	31 26	+17 38.3	0.88	293.	Heid.	14.4	0.121	10.1		162	+ 6
186	47252	CPD−68° 536	8.5	K0	32 29	−68 37.0	0.498	195.3	U.C. 19	12.0				246	−26
187	48915	α*Canis Majoris*	−1.58	A0	40 45	−16 34.7	1.316	203.6	P.G.C.	4.0	0.374	1.3	− 8.	194	− 8
188		Comp to α *Can. Maj.*	8.44	F	40 45	−16 34.7	1.316	203.6	P.G.C.	14.6	0.374	11.3		194	− 8
189			*10.*		40 56	+37 39.2	0.95	191.	A.N. **207**, 171	14.9				145	+16
190	50281	Strb 2339	6.77	K2	47 26	− 5 3.2	0.582	268.6	Ci. 18	10.6	0.128	7.3		185	− 1
191		Wolf 294	*10.5*	Ma	48 21	+33 24.0	0.84	240.	Heid.	15.6				151	+16
192	50806	90 *Canis Majoris*	6.03	G0	49 35	−28 24.2	0.524	146.3	P.G.C.	9.6				206	−11
193	51219	Alb 2511	7.7	G5	51 24	+ 1 18.5	0.57	180.0	Ci. 18	11.5	0.028	4.9	−12.	180	+ 3
194	51866	Bo 5676	8.2	K0	54 0	+48 31.8	0.697	127.8	Ci. 18	12.4	0.032	5.7	−22.3	136	+22
195	52711	Cbr E 3695	5.95	F8	57 9	+29 30.3	0.838	169 2	P.G.C.	10.6	0.062	5.0	+20.3	155	+16
196	54563	Be B 2813	6.46	G5	7 4 11	+21 25.3	0.510	199.2	Ci. 18	10.0	0.040	4.5	−14.	163	+13
197	55720	Cordoba 9154	7.8	G5	8 53	−49 16.7	0.74	0.0	Ci. 18	12.1				227	−16
198			*11.*		11 8	−66 56.5	0.701	172.	U.C. 53	15.5				247	−22
199	56274	Harv II 2504	7.72	G5	11 16	−12 52.7	0.513	287.5	Ci. 18	11.3	0.041	5.8	+57.0	194	0
200		BD+33° 1505	9.3		12 58	+33 1.6	0.57	127.	A.N. **207**, 171	13.1				153	+20
201	57095	Cordoba 9329	7.6	K0	14 37	−46 48.8	0.585	355.1	Ci. 18	11.4				224	−14
202		CPD−45° 1588	*9.8*		31 15	−45 4.2	0.555	322.5	U.C. 39	13.2				225	−11
203		BD+37 1748	9.5		31 35	+36 57.3	0.87	173.	A.N. **207**, 171	14.2				150	+25
204	61421	α *Canis Minoris*	0.48	F5	34 4	+ 5 28.9	1.242	214.0	P.G.C.	6.0	0.313	3.0	−4.3	182	+14
205		Comp to α *Can Min*	13.0		34 4	+ 5 28.9	1.242	214.0	P.G.C.	18.5	0.313	15.5		182	+14
206	62301	Lund 3966	6.75	F8	38 8	+39 48.8	0.685	175.5	Ci. 18+Fi.Ac.	11.0	0.029	4.1		147	+27
207*	62363	CPD−69° 757	83	F0	38 24	−69 50.3	0.614	208.3	U.C. 19	12.2				249	−21
208	62509	β *Geminorum*	1.21	K0	39 12	+28 16.1	0.625	264.6	P.G.C.	5.2	0 095	1 1	+ 3.6	159	+24
209	62644	159 *Puppis* [T]	5.22	G5	39 51	−44 55.2	0.572	187.2	P.G.C.	9.0			+23.	225	− 9
210		Cbr M 2950	8.6		40 50	+53 54.8	0.56	193.2	L. O. Bull. **10**, 22	12.1				131	+30
211	63077	171 *Puppis*	5.39	F8	41 51	−33 58.5	1.710	351.3	P.G.C.	11.6			+100.	217	− 4
212	63452	CPD−48° 1280	9.2	A3	43 49	−48 39.4	0.497	273.5	U.C. 19	12.7				229	−11
213*	64090	Lei 3313	8.2	G0	47 10	+30 54.8	1.962	158.1	Ci. 18	14.7	0.050	6.7	−242.	158	+26
214		Hels Astr 330, 114	*11.0*		50 47	+40 19.0	0.599	190.8	Finn. Acad.	14.9				147	+30
215	65430	Be B 3201	8.6	G5	53 41	+21 7.8	0.573	161.9	Ci. 18	12.4	0.042	6.7		168	+25
216		Wolf 1059	*11.*		54 18	+29 17.6	0.58	184.	A.N. **210**, 387	15.2				160	+27
217	65583	Cbr E 4285	6.94	G0	54 21	+29 31.1	1.170	188.2	Ci. 18	12.3	0.062	5.9	+14.	160	+27
218	65907	69 *Carinae*	5.66	F8	55 56	−60 2.1	0.516	76.7	P.G.C.	9.3				241	−15
219		Comp. to 69 *Carinae*	*11.*		56 3	−60 1.9	0.516	76.7	P.G.C.+U.C. 46	14.9				241	−15
220	66171	Be C 1148	8.0	G0	57 13	+72 13.2	0.496	205.1	Ci. 18	11.5	0.035	5.7		110	+31

LIST OF STARS WHOSE ANNUAL PROPER MOTIONS ARE NOT LESS THAN 0".50—*Continued*

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
221	67458	Cord B 4791	6^{m}93	G0	8^{h} 2^{m}55^{s}	−29° 6'.3	0".546	137°.9	Ci. 18	10^{m}6				214°	+ 3°
222	68017	Lei 3421	6.95	G0	5 23	+32 46.3	0.806	214.7	P.G.C.	11.5	0.050	5.5	+27.	157	+30
223			*12.*		7 28	−52 41.4	0.819	316.0	U.C. 48	16.8				234	− 9
224	68788	Be C 1178	8.6	G5	8 47	+73 44.2	0.559	209.2	Ci. 18	12.3	0.019	5.0		109	+32
225		Harv II 3139	9.3		11 32	−11 27.1	0.72	59.0	A.N. **177**, 337	13.6				201	+13
226		Lei 3472	8.6	K5	12 0	+30 56.0	0.873	199.6	Ci. 18	13.3	0.044	6.9		160	+31
227	69830	Harv II 3159	6.04	G5	13 39	−12 17.6	1.030	164.2	P.G.C.	11.1	0.074	5.3	+27.5	202	+14
228	70352	Chri. 1340	8.9	K0	16 21	+66 47.9	0.52	180.0	Ci. 18	12.5	0.032	6.4		117	+34
229		BD+33° 1694	9.2		18 54	+32 57.3	0.69	173.	A.N. **207**, 171	13.4				157	+34
230		BD+46° 1405	9.5		22 32	+46 15.2	0.571	215.1	Finn. Acad.+Heid.	13.4				141	+36
231		BD+67 552	9.3		27 23	+67 40.3	1.101	267.2	Gr. Astr. 4	14.7	0.114	9.6		115	+35
232	72614	Bo 6668	8.6	G5	28 48	+42 6.1	0.66	199.7	Ci. 18	12.7	0.031	6.1		146	+37
233*	72673	11 *Pyxidis*	6.36	G5	28 57	−31 10.9	1.332	308.1	P.G.C.	12.0	0.005	−0.1	+34.	221	+ 6
234	73667	Lpz I 3494	7.9	G5	34 23	+11 53.4	0.531	191.3	Ci. 18	11.5	0.035	5.6		183	+31
235		Wolf 320	*13.*		35 51	+44 53.8	0.69	85.	Heid.	17.4				143	+39
236		Wolf 321	*13.*		36 34	+44 51.6	0.56	255.	Heid.	16.9				143	+39
237	74377	Bo 6764	8.2	K0	38 35	+42 3.1	0.702	202.5	P.G.C.	12.4	0.076	7.6		145	+39
238	74576	Cordoba 11812	6.63	K0	39 35	−38 31.8	0.496	314.8	U.C. 34	10.1	0.099	6.6		227	+ 3
239		BD+37 1912	9.5		42 57	+36 54.1	0.56	202.	A.N. **207**, 171	13.5				154	+39
240	75632	Be C 1255	9.3	K2	45 59	+71 10.9	1.390	254.9	Ci. 18	15.0	0.102	9.3		110	+35
241		Be C 1256	9.3	K2	45 59	+71 10.9	1.390	254.9	Ci. 18	15.0	0.102	9.3		110	+35
242	75732	55 ρ_1 *Cancri*	6.06	K0	46 39	+28 42.8	0.539	242.8	P.G.C.	9.8	0.085	5.7	+21.1	164	+38
243		Comp to ρ_1, *Cancri*	12.98	M?	46 43	+28 41.9	0.55	244.	A.S.P. **30**, 191	16.7	0.085	12.6		164	+38
244		Be B 3609	9.0		52 4	+20 52.0	0.73	103.	Heid.	14.1				174	+37
245*	76644	ι*Ursae Majoris* A	3.12	A5	52 22	+48 26.1	0.504	240.3	P.G.C.	6.6	0.065	2.2	+15.	138	+41
246		ι*Ursae Majoris* B	9.5		52 22	+48 26.1	0.504	240.3	P.G.C.	13.0	0.065	8.6		138	+41
247		ι*Ursae Majoris* C	9.8		52 22	+48 26.1	0.504	240.3	P.G.C.	13.3	0.065	8.9		138	+41
248*	76943	10 *Ursae Majoris*	4.09	F5	54 9	+42 10.7	0.505	238.8	P.G.C.	7.6	0.067	3.2	+25.5	147	+41
249		Oxf+Astr+26° 25798	*11.2*		59 53	+25 42.2	0.496	229.8	M.N. **69**, 491	13.9				169	+40
250	78558	Washington 3697	7.26	G0	9 3 46	−14 44.1	0.557	248.3	Ci. 18	11.0	0.033	4.9		211	+22
251		BD+77° 361	9.2		6 24	+77 39.5	1.060	268.6	Gr.Astr. 4	14.7				102	+33
252	79096	81 π_1 *Cancri*	6.40	G5	6 49	+15 23.9	0.575	294.2	P.G.C.	10.2	0.055	5.1	+45.9	182	+38
253	79210	Cbr M 3333	8.1	K2	7 34	+53 6.9	1.677	246.2	P.G.C.	14.2	0.152	9.0	+10.5	132	+42
254	79211	Cbr M 3335	8.1	K2	7 36	+53 7.0	1.687	246.2	P.G.C.	14.2	0.152	9.0	+10.5	132	+42
255	79969	Cbr E 4896	7.26	K0	11 57	+28 59.6	0.517	172.3	Ci. 18	10.9	0.055	6.0	−16.	164	+43
256	80715	Bo 7078	7.71	K2	16 8	+40 38.2	0.521	221.7	Ci. 18	11.3	0.046	6.1		149	+46
257	82106	Lpz II 5149	7.6	K2	24 42	+ 6 5.4	0.533	282.3	Ci. 18	11.2	0.063	6.6		195	+38
258		BD+36° 1970	9.3		25 46	+36 46.8	0.56	201.	A.N. **207**, 171	13.0				155	+47
259	82328	θ*Ursae Majoris*	3.26	F8	26 10	+52 8.0	1.094	239.8	P.G.C.	8.5	0.071	2.6	+15.8	132	+45
260		Comp to θ *Urs. Maj.*	13.7		26 10	+52 8.0	1.094	239.8	P.G.C.	18.9	0.071	13.0		132	+45
261	82885	11 *Leo. Minoris*	5.48	K0	29 40	+36 15.7	0.752	249.2	P.G.C.	9.9	0.101	5.5	+12.2	156	+49
262		Star near W *Urs. Maj.*	*14.*		35 27	+56 27.	0.924	238.4	A.S.P. **32**, 242	18.0	0.030	10.6		126	+46
263	84035	Bo 7254	8.1	K2	37 7	+43 10.3	0.819	177.1	Ci. 18	12.7	0.070	7.3	−12.9	145	+49
264		CPD−45° 3978	*9.9*		40 46	−45 17.8	0.724	223.5	U.C. 39	14.1				240	+ 7
265*	84937	Lpz I 3873	8.1	F0	43 28	+14 13.8	0.829	155.6	Ci. 18	12.7	0.004	1.1	−23.2	188	+46
266		Harv II 3768	9.4	Ma	46 10	−11 49.3	1.848	140.5	Ci. 18	15.7				218	+32
267	85512	Cordoba 13443	8.4	K5	47 4	−43 1.2	0.650	131.2	U.C. 34	12.5				239	+ 9
268		Hels 6113	8.5		48 47	+63 16.6	0.600	150.0	M.N. **80**, 757	12.9				115	+44
269	86661	Hels 6156	8.3	G5	54 53	+56 4.7	0.498	203.3	Ci. 18	11.8	0.056	7.0		124	+48
270		Wolf 335	*10.5*	Ma	55 1	+32 48.5	1.20	230.	Heid.	16.4				160	+53
271	86728	20 *Leo Minoris*	5.60	G5	55 15	+32 24.9	0.680	229.5	P.G.C.	9.8	0.068	4.8	+55.9	162	+53
272	88230	Bo 7493	6.82	K5	10 5 15	+49 57.6	1.451	249.7	Ci. 18	12.6	0.208	8.4	−30.	134	+52
273		Cbr M 3592	9.0	K3	7 28	+53 1.4	0.74	173.7	Ci. 18	13.3	0.063	8.0		127	+52
274		BD+10° 2122	9.3		7 52	+10 4.5	0.626	180.	B-Z.A.N. **2**, 71	13.3				198	+50
275		CPD−51° 3156	*9.8*		13 21	−51 59.5	0.643	90.0	U.C. 48	13.7				249	+ 4

LIST OF STARS WHOSE ANNUAL PROPER MOTIONS ARE NOT LESS THAN 0″50—*Continued*

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
276	89668	Nic 3038	8^m9	K0	$10^h15^m42^s$	− 0°57′.7	0″679	256°3	Ci. 18	13^m1	0″050	7^m4		213°	+45°
277	90508	Bo 7627	6.50	G0	21 54	+49 19.1	0.898	174.4	P.G.C.	11.3	0.080	6.0	− 8.	133	+55
278		BD+46° 1635	8.8		25 29	+46 3.3	0.837	224.7	Finn. Acad.	13.4				137	+57
279	91889	236 *Hydrae*	5.85	F8	31 34	−11 41.6	0.731	158.6	P.G.C.	10.2	0.019	2.2		227	+40
280		Wolf 358	*11.*		45 44	+ 7 21.2	1.19	226.0	Heid.	16.8				210	+56
281	94028	Be B 4118	8.1	F5	46 7	+20 49.2	0.502	208.8	Ci. 18	11.6	0.022	4.8		187	+63
282			*13.2*		46 23	+14 31.5	1.07	280.5	A.J. **29**, 168	18.2				202	+61
283		Be C 1500	9.5		50 59	+70 7.7	0.634	275.0	Gr. Astr. 4	13.7	0.064	8.5		103	+44
284		Bo 7830	9.0		51 25	+42 25.6	0.745	247.8	Finn. Acad.	13.4				138	+63
285		Wolf 359	*13.*		51 38	+ 7 36.4	4.84	232.	Heid.	21.6	0.404			212	+58
286		CPD−55° 4033	*9.4*		55 3	−56 5.0	0.578	256.7	U.C. 48	13.0				225	+ 3
287*	95735	22H *Camelopardalis*	7.60	Ma	57 52	+36 38.4	4.778	186.8	P.G.C.	16.0	0.409	10.7	−87.	153	+66
288*		Bo 7899	8.9	Ma	11 0 31	+44 2.4	4.519	282.1	Ci. 18	17.2	0.209	10.5	+65.	134	+63
289		Wolf 362	*13.*		2 9	+ 2 9.3	0.67	146.	Heid.	17.3				227	+55
290	96700	Cord B 7330	6.53	G0	3 9	−29 37.8	0.546	253.6	Ci. 18	10.2				245	+29
291		Comp to Lei 4377	9.5	Ma	5 32	+30 59.7	0.623	108.6	Ci. 18	13.5	0.070	8.7		164	+68
292	97101	Lei 4377	8.8	K5	5 36	+30 59.7	0.623	108.6	Ci. 18	12.8	0.070	8.0		164	+68
293			*11.1*		5 50	+45 58.4	0.753	233.8	Finn. Acad.	15.5				129	+63
294		Wolf 365	*10.*		5 54	+ 6 58.6	0.82	228.	Heid.	15.1				217	+60
295	97233	Washington 4420	9.3	K5	6 29	−14 25.9	0.92	129.2	Ci. 18	14.1				227	+42
296		Wolf 368	*13.5*		7 45	+13 27.7	0.84	130.	Heid.	18.2				206	+63
297		Wolf 373	*12.5*		10 58	+ 8 33.4	0.81	262.	Heid.	17.3				218	+62
298			*12.5*		12 0	−57 2.2	2.718	292.6	U.C. 48	18.9	0.337	14.3		258	+ 4
299		Nic 3220	8.8		12 11	− 1 26.1	0.53	268.9	Ci. 18	12.4				230	+54
300	89231	ξ *Ursae Majoris* A	4.41	G0	12 51	+32 5.5	0.733	215.3	P.G.C.	8.7	0.150	5.3	−16.	161	+69
301	98230	ξ *Ursae Majoris* B	4.87	G0	12 51	+32 5.5	0.733	215.3	P.G.C.	9.2	0.150	5.8		161	+69
302*		ξ *Ursae Majoris* C			12 51	+32 5.5	0.733	215.3	P.G.C.		0.150			161	+69
303	98281	Strb 4271	7.34	K0	13 11	− 4 31.0	0.805	100.2	P.G.C.	11.8	0.041	5.4		233	+51
304		Chri. 1745	9.2	Ma	14 50	+66 23.3	2.986	273.4	Ci. 18	16.6	0.215	10.9		103	+48
305		BD+15° 2325	9.5		17 9	+14 59.5	0.54	270.	Heid.	13.5				207	+67
306		Wolf 386	*10.*		18 39	+ 9 6.7	1.05	279.	Heid.	15.6				219	+63
307	99279	Cordoba 15615	7.4	K5	20 20	−61 6.1	0.513	278.3	U.C. 19	11.0				260	0
308		Wolf 391	*12.*		20 23	+ 1 30.8	0.59	180.	Heid.	16.2				229	+58
309	99491	83_1 *Leonis*	6.54	K0	21 42	+ 3 33.5	0.743	283.0	P.G.C.	10.6	0.036	4.3	+ 2.4	228	+60
310	99492	83_2 *Leonis*	7.58	K0	21 43	+ 3 33.1	0.736	283.0	P.G.C.	12.2	0.036	5.4	+ 2.2	228	+60
311		Wolf 395	*13.*		21 47	+12 25.0	0.50	275.	Heid.	16.7				214	+67
312			9.7		23 20	+ 8 6.1	1.16	191.9	Ci. 18	15.3				223	+64
313		Wolf 398	*11.5*		23 49	+10 42.8	0.99	300.	Heid.	16.8				219	+66
314		CPD−56° 4554	*9.5*		26 3	−56 35.4	0.601	275.3	U.C. 48	13.3				260	+ 5
315		Hels Astr 48428	*10.6*		29 18	+40 43.4	0.643	222.9	Finn. Acad.	14.6				130	+69
316	100623	289 *Hydrae*	6.14	G5	29 38	−32 18.1	1.057	320.3	P.G.C.	11.2	0.170	7.3	−24.	252	+28
317		BD+40° 2442	*10.1*		31.17	+39 45.3	0.602	130.0	Finn. Acad.	14.0				133	+71
318		Bo 8133	8.6	K5	33 28	+45 39.7	0.583	271.9	P.G.C.	12.4	0.040	6.6		124	+68
319	101177	Bo 8134	6.34	G0	33 29	+45 39.7	0.583	271.9	P.G.C.	10.1	0.040	4.3	−17.6	124	+68
320	101581	CPD−43° 5524	7.4	K5	36 14	−43 51.5	0.718	285.3	U.C. 19	11.7				257	+18
321			*10.*		40 10	−64 16.7	2.69	99.	U.C. 37	17.2				264	− 2
322	102158	Bo 8183	8.0	G0	40 18	+48 13.8	0.644	243.6	Ci. 18	12.0	0.021	4.6	+23.9	117	+65
323	102365	66 *Centauri*	5.04	G5	41 45	−39 57.4	1.573	284.3	P.G.C.	11.0			+17.5	258	+22
324		CPD−65° 1714_1	*10.*		42 12	−65 18.8	0.55	256.	U.C. 37	13.8				265	− 3
325		CPD−65° 1714_2	*11.*		42 12	−65 18.8	0.55	256.	U.C. 37	14.9				265	− 3
326	102647	β *Leonis*	2.23	A2	43 57	+15 7.8	0.509	256.0	P.G.C.	5.7	0.109	2.4	+ 1.3	217	+71
327	102870	β *Virginis*	3.80	F8	45 29	+ 2 19.7	0.793	110.7	P.G.C.	8.3	0.105	3.9	+ 4.6	238	+61
328*	103095	Lund 5297	6.46	G5	47 13	+38 26.2	7.047	145.3	P.G.C.	15.7	0.108	6.7	−97.0	133	+74
329	103932	Cord B 7792	7.16	K5	52 58	−27 8.0	1.243	239.7	Ci. 18	12.7	0.083	6.8		256	+34
330	104556	Bo 8315	6.83	K0	57 25	+43 39.3	0.629	214.3	P.G.C.	10.8	0.005	0.3	−13.	118	+72

LIST OF STARS WHOSE ANNUAL PROPER MOTIONS ARE NOT LESS THAN 0″.50—*Continued*

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
331	104800	Alb 4409	$9^{m}3$	G0	$11^{h}58^{m}58^{s}$	+ 3°54′.8	0″.567	172°.0	Ci. 18	$13^{m}1$	0″.019	$5^{m}7$		244°	+65°
332	104988	Nic 3352	8.4	G5	12 0 9	− 0 57.2	0.531	275.6	Ci. 18	12.0	0.100	8.4		248	+61
333		Wolf 406	*10.*		3 18	+ 0 3.3	1.07	261.	Heid.	15.7				249	+62
334	106116	Strb 4527	7.36	G0	7 25	− 2 32.4	0.732	305.9	Ci. 18	11.7	0.026	4.5	+11.3	251	+59
335	106210	Lpz I 4515	7.9	G5	8 7	+11 23.7	0.589	178.7	Ci. 18	11.8	0.044	6.1	−30.0	242	+73
336	106516	W Ott 4511	6.12	F8	10 2	− 9 43.7	1.024	177.1	Ci. 18	11.2	0.041	4.2		257	+53
337		BD+29° 2279	9.5		14 28	+28 56.2	0.64	265.	Heid.	14.0				165	+84
338	107596	Bo 8468	9.1	Ma	16 56	+42 42.2	0.57	158.4	Ci. 18	12.9	0.076	8.5		110	+73
339		Wolf 409	*11.*		17 25	+25 43.8	0.73	260.	Heid.	15.7				190	+85
340	107773	Cordoba 16878	6.38	K0	17 51	−67 5.0	0.816	287.2	Ci. 18	11.0				267	− 4
341	107760	Be C 1671	8.2	G5	17 55	+73 47.9	0.507	292.0	Ci.18+Gr.Astr. 4	11.7				93	+43
342	108076	Lund 5422	8.10	G0	19 55	+38 52.3	0.596	272.9	Lund	12.0	0.017	4.3		111	+77
343	108309	Cordoba 16955	6.22	G0	21 31	−48 21.4	0.64	261.8	Ci. 18	10.2				266	+14
344		Wolf 414	*10.5*		23 56	+ 8 59.3	0.70	232.	Heid.	15.2				257	+71
345	108754	Strb 4605	8.7	G5	24 37	− 2 45.9	0.721	209.4	Ci. 18	13.0	0.071	8.0		261	+60
346		Lpz II 6152	8.8	Ma	26 16	+ 9 22.8	0.96	234.	Heid.	14.2				259	+71
347	109200	Cordoba 17104	7.3	G5	27 49	−68 11.7	0.541	247.8	U.C. 19	11.0				268	− 5
348		Wolf 424	*12.*		28 25	+ 9 33.9	1.87	276.	Heid.	18.7				261	+71
349	109358	*β Can Venat*	4.32	G0	29 0	+41 54.0	0.755	291.8	P.G.C.	8.7	0.104	4.4	+ 6.	97	+76
350		Wolf 427	*10.5*		30 1	+10 23.2	0.66	235.	Heid.	14.9				254	+73
351		Wolf 429	*14.*		30 50	+ 7 19.0	0.59	225.	Heid.	18.0				257	+69
352	109952	CPD−77° 859	9.0	K5	33 33	−77 18.2	0.831	294.1	U.C. 19	13.6				269	−14
353		Wolf 433	*10.5*		33 58	+12 15.0	1.16	261.	Heid.	16.3				262	+74
354	110379	γ_1 *Virginis*	3.65	F0	36 36	− 0 54.1	0.564	270.4	P.G.C.	7.4	0.058	2.4	−20.0	267	+62
355	110380	γ_2 *Virginis*	3.68	F0	36 36	− 0 54.1	0.564	270.4	P.G.C.	7.5	0.058	2.5	−20.0	267	+62
356	110619	Cordoba 17329	7.50	G0	38 24	−37 9.3	0.707	251.0	U.C. 19	11.7				228	+27
357*	111028	33 *Virginis*	5.86	K0	41 18	+10 5.9	0.530	149.4	P.G.C.	9.5	0.006	−0.2	+51.0	269	+72
358		Wolf 437	*11.*		43 1	+10 18.4	1.03	244.	Heid.	16.5				270	+72
359		Wolf 438	*13.*		43 2	+10 12.7	0.90	270.	Heid.	18.0				270	+72
360		Wolf 439	*12.*		44 34	+10 1.3	0.64	270.	Heid.	16.3				270	+72
361	111515	Alb 4578	8.1	G5	44 39	+ 1 45.1	0.665	186.6	Ci. 18	12.2	0.038	6.0		272	+64
362	111777	La Plata I 3969	8.3	G0	46 33	−56 1.2	0.599	254.4	U.C. 48	12.2				271	+ 7
363*	111980	Washington 4921	8.3	F8	47 56	−17 57.4	0.877	159.1	Ci. 18	13.0	0.011	3.5	+144.	271	+45
364	112575	Harv II 4657	8.9	K2	52 31	−13 55.4	0.54	252.	A.N. **211**, 223	12.6				274	+49
365	112758	W Ott 4688	7.7	G5	53 54	− 9 18.0	0.850	283.1	Ci. 18	12.3	0.029	5.0		275	+54
366		Wolf 457	*13.5*		55 6	+ 4 2.3	1.05	210.	Heid.	18.7				277	+67
367		Wolf 458	*12.*		55 13	+ 6 7.2	0.61	110.	Heid.	16.2				277	+69
368	112943	Nic 3508	9.5	K2	55 14	− 2 9.9	0.73	270.0	Ci. 18	13.8				276	+60
369		Wolf 461	*12.*		55 35	+ 6 12.9	1.01	290.	Heid.	17.3				282	+69
370		Wolf 462	*10.5*		55 50	+12 54.7	0.74	265.	Heid.	15.3				282	+75
371	113083	Cord A 9699	8.2	G0	56 5	−26 49.8	0.545	244.8	Ci. 18	11.9	0.013	3.8		273	+36
372	113538	CPD−51° 5750	9.0	K5	59 15	−51 53.1	1.162	224.0	U.C. 48	14.3				273	+11
373	114076	CPD−40° 6050	9.2	G5	13 2 58	−41 6.4	0.690	268.3	U.C. 19	13.4				274	+22
374	114094	BD+4° 2696	9.5	G	3 10	+ 4 18.8	0.54	235.	Heid.	13.2				283	+66
375	114174	Lpz II 6330	6.91	G0	3 47	+ 5 45.6	0.682	173.7	Ci. 18	11.1	0.033	4.5	+22.	284	+68
376	114606	Lpz I 4788	8.5	G0	6 25	+10 9.0	0.559	297.0	Ci. 18	12.2	0.023	5.3		289	+73
377		Comp to Lpz I 4788	*11.5*		6 26	+10 7.7	0.559	297.0	Ci. 18 + Heid.	15.5	0.023	9.4		289	+73
378	114692	CPD−34° 5560	7.57	F5	6 59	−34 12.6	0.509	225.0	U.C. 19	11.1				275	+29
379	114703	Chri 1979	8.8	G5	7 2	+68 1.6	0.75	266.9	Ci. 18	13.2	0.024	5.7		87	+49
380	114710	43 *Comae*	4.32	G0	7 12	+28 23.1	1.184	317.6	P.G.C.	9.7	0.128	4.8	+ 6.1	12	+84
381	114762	Be A 4855	7.7	F8	7 29	+18 2.9	0.578	267.9	Ci. 18	11.5	0.021	4.3		308	+80
382	115404	Be A 4874	6.55	K0	11 53	+17 33.1	0.691	112.9	Ci. 18	10.8	0.067	5.8		306	+78
383		Comp to Be A 4874	10.1		11 53	+17 33.1	0.691	112.9	Ci. 18	14.3	0.067	9.3		306	+78
384	115617	61 *Virginis*	4.80	G5	13 10	−17 45.3	1.527	224.0	P.G.C.	10.7	0.133	5.4	− 6.6	280	+46
385		Lund 5723	9.6	Ma	14 54	+35 39.4	0.884	154.3	Ci. 18	14.3	0.084	9.3		52	+78

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
386		Comp to Lund 5723	11^{m}.5		13^{h}14^{m}55^{s}	+35°39′.3	0″.884	154°.3	Ci. 18	16^{m}.5	0″.084	11^{m}.1		52°	+78°
387	116012	Alb 4699	8.80	K2	15 43	+ 4 39.1	0.575	292.3	Ci. 18	12.6	0.033	6.4		287	+67
388		Wolf 482	*11.*		18 31	−13 30.5	0.61	233.	Heid.	15.2				283	+49
389	116495	Cbr E 6460	8.86	K5	18 55	+29 45.2	0.535	297.1	Ci. 18	12.5				19	+81
390	117176	70 *Virginis*	5.16	G0	23 32	+14 18.8	0.634	202.6	P.G.C.	9.2	0.062	4.2	+ 4.9	311	+75
391*	117421	BD−7° 3632	9.6	F8	25 7	− 8 3.4	1.19	250.	Heid.	15.0				288	+52
392	117635	Nic 3594	7.31	G5	26 36	− 1 48.6	0.887	287.5	Ci. 18	12.0	0.040	5.3	−53.9	292	+60
393	117848	Cord B 8592	9.6	G0	27 51	−27 9.8	0.515	280.1	U.C. 19	13.2				282	+35
394	117854	Cordoba 18442	7.4	G5	27 54	−58 59.8	0.509	245.6	U.C. 19	10.9				276	+ 4
395*	117939	Cordoba 18463	7.14	G0	28 40	−38 22.9	0.50	135.	U.C. 19	10.6				280	+24
396		Wolf 489	*13.*		31 49	+ 4 12.8	3.94	252.	Heid.	21.2				300	+65
397		Nic 3625	9.0		36 50	+ 0 23.4	0.545	207.5	A.N. **213**, 231	12.7				300	+60
398		Be A 4999	9.6	Ma	40 14	+18 20.3	1.86	166.7	Ci. 18	16.0	0.099	9.6		330	+73
399	119850	Be A 5003	8.5	Ma	40 40	+15 26.0	2.298	129.6	Ci. 18	15.3	0.216	10.2		324	+72
400	119893	Cordoba 18714	8.2	K2	40 56	−35 54.2	0.935	271.2	U.C. 19	13.1				283	+26
401	120066	Lpz II 6504	6.32	G0	42 0	+ 6 51.2	0.499	256.7	P.G.C.	9.8	0.035	4.1		307	+64
402		BD−5° 3763	9.0		42 14	− 5 37.0	0.58	250.	Heid.	12.8				295	+54
403		BD+7° 2692	10.1	K0	42 32	+ 6 49.0	0.503	260.0	A.J. **32**, 96	13.6	0.035	7.9		307	+64
404	120237	Cordoba 18761	6.47	G0	43 10	−35 12.0	0.607	251.7	U.C. 19	10.4				284	+26
405	120467	BD−21° 3781	7.9	K5	44 27	−21 35.9	1.766	253.4	A.J. **34**, 11	14.1				288	+40
406	120559	La Plata I 4383	7.7	G0	45 4	−56 55.6	0.607	250.0	U.C. 19+48	11.6				278	+ 5
407	120690	Cord A 10124	6.48	G0	45 50	−23 53.2	0.658	243.5	Ci. 18	10.6	0.066	5.6		288	+37
408	120780	Cordoba 18837	7.54	G5	46 20	−50 25.6	0.647	267.6	Ci. 18	11.6				280	+12
409		Cp. to Gr.As.+66°4140	*13.0*		50 12	+66 7.0	0.575	257.6	U.C. 43	16.8				80	+50
410		BD+34° 2476	9.3		54 47	+34 23.4	0.54	161.	A.N. **207**, 171	13.5				28	+73
411		Oxf Astr+25° 86067	*10.4*		54 49	+25 44.2	0.54	262.4	M.N. **72**, 65	14.1	0.014	6.1		3	+73
412		Bo 9239	8.8		58 31	+46 49.4	0.609	95.3	Finn. Acad.	12.7				55	+66
413	123139	*θ Centauri*	2.26	K0	14 0 48	−35 52.7	0.747	225.0	P.G.C.	6.7	0.045	0.5	+ 1.8	287	+24
414			*14.0*		8 46	−13 18.9	0.73	242.2	A.J. **29**, 168	18.3				300	+44
415		BD+81° 465	9.5		10 22	+80 51.4	0.579	161.5	Gr.Astr. 4	13.6				85	+36
416	124897	*αBoötis*	0.24	K0	11 6	+19 42.2	2.282	208.8	P.G.C.	7.0	0.111	0.4	− 5.0	344	+69
417	125072	Cordoba 19334	7.0	K0	12 0	−58 53.7	0.930	210.0	U.C. 19+48	11.8				281	+ 2
418	125244	CPD−63° 3218	9.0	K0	12 59	−64 0.2	0.505	199.7	U.C. 48	12.5				279	− 3
419	125276	374 *Hydrae*	5.92	F5	13.20	−25 21.8	0.537	43.5	P.G.C.	9.6	0.036	3.7		296	+33
420		Comp to 374 *Hydrae*	13.3		13 20	−25 21.8	0.537	43.5	P.G.C.+Bu.	17.0	0.036	11.1		296	+33
421		Wolf 534	*11.5*		14 0	− 6 49.5	1.36	227.	Heid.	17.5				307	+50
422	125455	Strb 5091	7.6	K0	14 25	− 4 41.3	0.664	261.2	Ci. 18	11.7	0.105	7.7	−13.0	308	+53
423		Lei. 5169	8.6	K5	17 39	+30 5.7	0.727	241.9	Ci. 18	12.9	0.091	8.4		14	+69
424	126053	Alb 4941	6.34	G0	18 8	+ 1 42.6	0.525	157.5	Ci. 18	9.9	0.081	5.8	−17.8	315	+56
425		Be B 5072	9.5	Ma	21 5	+24 6.0	1.39	144.3	Ci. 18	15.2	0.070	8.7		358	+67
426		Be B 5073	9.6	Ma	21 8	+24 6.2	1.40	144.7	Ci. 18	15.5	0.070	8.8		358	+67
427			*11.0*		22 8	+53 47.2	0.52	213.1	A.J. **29**, 168	14.8				62	+58
428*		Proxima *Centauri*	10.5	M?	22 55	−62 15.2	3.852	282.9	U.C. 40	18.4	0.761	14.9		281	− 2
429		BD+24° 2735	9.5		23 17	+24 17.5	0.499	273.1	M.N. **72**, 65	13.2				0	+67
430	127339	BD−7° 3856	9.3	K5	25 37	− 8 11.7	1.26	261.8	Ci. 18	14.8				304	+48
431	127506	Lund 6145	8.2	G5	26 40	+35 53.2	0.51	288.	A.N. 207, 171	11.7				27	+66
432	127871	Lpz I 5137	8.92	G5	28 40	+ 9 47.3	0.55	161.2	Ci. 18	12.6	0.029	6.2		330	+59
433		Lei 5231	9.0		30 52	+34 10.6	0.76	286.7	Ci. 18	13.6				25	+65
434	128429	Harv II 5129	6.24	F8	31 41	−11 52.8	0.944	292.6	P.G.C.	11.1	0.040	4.2	−70.5	306	+44
435	128620	α_1 *Centauri*	0.33	G0	32 48	−60 25.4	3.680	281.4	P.G.C.	8.1	0.763	4.7	+22.2	283	0
436	128621	α_2 *Centauri*	1.70	K5	32 48	−60 25.4	3.680	281.4	P.G.C.	9.5	0.763	6.1	+22.2	283	0
437		Wolf 536	*10.5*		33 7	− 0 24.5	0.56	270.	Heid.	14.7				318	+52
438	128674	La Plata I 4647	7.42	G5	33 7	−56 35.5	0.584	131.8	U.C. 48	11.2				285	+ 3
439		Wolf 537	*13.5*		36 58	+ 2 22.6	0.66	160.	Heid.	17.7				323	+53
440		BD+6° 2932	9.5		38 27	+ 6 14.7	0.93	260.	Heid.	14.3				327	+56

LIST OF STARS WHOSE ANNUAL PROPER MOTIONS ARE NOT LESS THAN 0″.50—*Continued*

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
441		Wolf 541	*12^m*		$14^h38^m31^s$	− 1° 5′.8	0″.53	225°.	Heid.	$15^m.9$				319°	+50°
442		Be A 5335	8.9		41 43	+16 56.5	0.97	187.7	Ci. 18	13.8				344	+60
443	130871	Lpz II 6820	9.4	K0	45 29	+ 7 13.8	0.603	263.9	Ci. 18	13.3				333	+54
444	130992	Cord A 10660	7.7	K2	46 0	−23 52.8	1.022	245.1	Ci. 18	12.8	0.063	6.7		303	+31
445		Wolf 553	*12.5*		46 7	− 1 6.7	0.65	225.	Heid.	16.9				320	+49
446		Wolf 554	*10.*		47 9	+ 5 48.7	0.55	215.	Heid.	13.2				329	+53
447	131582	Be B 5191	8.8	K2	49 20	+23 45.2	0.817	270.6	Ci. 18	13.4	0.044	6.9		3	+60
448	131976	Cp. to Cordoba 20257	8.9	Ma	51 36	−20 57.7	1.916	150.3	P.G.C.	15.3	0.171	10.1		307	+34
449	131977	Cordoba 20257	5.76	K5	51 37	−20 57.8	2.039	149.3	P.G.C.	12.3	0.171	7.0	+20.1	307	+34
450		Gr Astr+72° 6399	*11.8*	Ma	52 0	+72 5.0	0.919	244.6	Gr. Astr. 4	15.6				77	+42
451	132142	Cbr M 4641	7.9	G5	52 21	+54 4.3	1.086	296.9	Ci. 18	13.1	0.056	6.7	−14.4	58	+55
452*	132475	BD−21° 4009	8.5	F8	54 9	−21 36.0	0.785	229.0	Ci. 18	13.0	0.009	3.3	+159.	308	+34
453	133421	CPD−48° 7086	8.5	K0	59 14	−48 52.7	0.553	186.1	U.C. 19	12.2				292	+ 9
454	134113	Lpz II 6905	8.7	G0	15 2 58	+ 9 15.9	0.534	262.6	Ci. 18	12.3	0.013	4.3		337	+53
455		Cbr E 7086	9.2		3 8	+25 18.4	0.961	300.7	Ci. 18	14.1	0.080	8.7		6	+59
456		BD+32° 2547	9.5		3 37	+32 46.4	0.59	183.	A.N. **207**, 171	13.4				19	+60
457*	134440	Washington 5583	9.9	G5	4 44	−15 59.0	3.682	195.7	Ci. 18	17.7	0.029	7.2	+307.	314	+35
458*	134439	Washington 5584	9.4	G0	4 45	−15 54.0	3.682	195.7	Ci. 18	17.2	0.029	6.7	+295.	314	+35
459	135101	Be A 5479	6.83	G5	8 15	+19 39.2	0.661	295.9	Ci. 18	10.9	0.030	4.2	−35.	352	+55
460		Be A 5480	7.63	G5	8 16	+19 39.6	0.661	295.9	Ci. 18	11.7	0.030	5.0		352	+55
461	135204	Nic 3891_1	6.7	K0	8 50	− 0 57.8	1.376	248.4	Ci. 18	12.4	0.069	5.9	−70.	327	+45
462		Nic 3891_2	6.7	K0	8 50	− 0 57.8	1.376	248.4	Ci. 18	12.4	0.069	5.9		327	+45
463		Strb 5325	9.2		8 51	− 3 25.8	0.69	290.	Heid.	13.4				325	+43
464	136202	5 *Serpentis*	5.18	G0	14 12	+ 2 8.6	0.644	145.0	P.G.C.	9.2	0.052	3.8	+53.8	333	+47
465		Comp to 5 *Serp*	10.0		14 13	+ 2 8.7	0.644	145.0	P.G.C.	14.0	0.052	8.6		333	+47
466		BD−7° 4003	9.2	Ma	14 14	− 7 21.3	1.33	260.	Heid.	14.8				323	+40
467	136274	Cbr E 7155	8.1	G0	14 44	+26 3.5	0.568	256.7	Ci. 18	11.9	0.033	5.7		6	+56
468	136352	85 ν_2 *Lupi*	5.71	G0	15 3	−47 57.0	1.663	260.5	P.G.C.	11.8			−69.	296	+ 9
469		Comp to ν_2 *Lupi*	9.0		15 3	−47 57.0	1.663	260.5	P.G.C.	15.1				296	+ 9
470		Wolf 563	*10.5*		15 31	−12 48.7	0.75	240.	Heid.	15.4				318	+36
471	136834	Alb 5192	8.7	K0	17 41	+ 1 47.2	0.507	226.8	Ci. 18	12.2	0.105	8.8		332	+44
472		Cp to CPD−54° 6618	*13.5*		32 1	−54 48.0	1.306	189.7	U.C. 48	19.1				293	0
473	140283	Harv II 5477	7.26	F5	37 42	−10 36.4	1.178	255.6	Ci. 18	12.7	0.036	5.1	−170.	323	+33
474			*12.*		40 0	−57 51.8	0.692	244.5	U.C. 48	16.2				291	− 3
475	140901	Cordoba 21374	6.12	G0	40.59	−37 36.0	0.525	239.3	Ci. 18	9.7				304	+14
476	142267	39 *Serpentis*	6.16	G0	48 33	+13 30.6	0.586	196.1	P.G.C.	10.0	0.041	4.3	+38.7	353	+44
477	142373	χ *Herculis*	4.61	G0	49 13	+42 43.9	0.760	35.7	P.G.C.	9.0	0.102	4.6	−55.6	35	+49
478*	142604	CPD−47° 7499	9.5	B9	50 15	−47 20.6	0.850	262.6	U.C. 19	14.1				300	+ 4
479	142860	γ *Serpentis*	3.86	F5	51 50	+15 59.3	1.332	166.8	P.G.C.	9.5	0.094	3.8	+ 7.3	354	+45
480*		Wolf 611	*16.*		52 15	+ 5 25.5	1.54	180.	Heid.	21.8				343	+40
481*		Wolf 612	*13.5*		52 17	+ 5 26.5	1.43	180.	Heid.	19.4				343	+40
482	143291	Cbr E 7420	8.1	K0	54 31	+28 1.0	0.85	290.7	Ci. 18	12.7	0.042	6.2		12	+47
483	143333	49 *Librae*	5.53	F8	54 43	−16 14.3	0.750	237.8	P.G.C.	9.9	0.042	3.6		323	+26
484		Wolf 624	*12.5*		56 27	+ 5 40.9	0.51	230.	Heid.	16.3				344	+39
485	143761	ρ*Coronae Borealis*	5.43	F8	57 13	+33 36.3	0.809	195.3	P.G.C.	9.9	0.040	3.4	+20.1	21	+48
486	144287	Cbr E 7468	7.06	G0	59 55	+25 30.6	0.862	323.2	Ci. 18	11.8	0.058	5.9		9	+46
487	144579	Lund 6612	6.84	G5	16 1 30	+39 25.6	0.571	275.3	Ci. 18	10.6	0.075	6.2	−60.	30	+47
488	144872	Lund 6621	8.6	G5	2 54	+38 54.9	0.591	157.5	Ci. 18	12.5	0.042	6.7		29	+48
489		BD+35° 2774	9.5		2 54	+34 55.1	0.64	156.	A.N. **207**, 171	13.7				23	+47
490		CPD−52 9317	*10.5*		4 7	−52 39.0	0.548	200.0	U.C. 48	14.3				298	− 1
491	145148	Lpz II 7207	6.02	G5	4 16	+ 6 39.8	0.760	162.8	Ci. 18	10.4	0.026	3.1	− 2.3	346	+38
492	145417	Cordoba 21928	7.3	G5	5 44	−57 16.0	1.568	212.7	U.C. 48	13.3				295	− 5
493	146233	18 *Scorpii*	5.56	G0	10 11	− 8 6.3	0.562	156.5	P.G.C.	9.4	0.057	4.4	+11.2	333	+28
494	147379	Chri 2448	8.9	K5	16 32	+67 28.7	0.505	280.3	Ci. 18	12.4	0.129	9.5		68	+37
495		Comp to Chri 2448	10.6	Ma	16 34	+67 30.0	0.505	280.3	Ci. 18	14.1	0.129	11.2		68	+37

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
496			*11*^{m}*5*		16^{h}20^{m} 3^{s}	−60°13′.6	1″.114	55°.7	U.C. 48	16^{m}8				294°	− 8°
497			*10.7*	Mb	21 7	+48 36.2	1.232	111.4	G.P. 19	16.2	0.133	11.3		42	+43
498	148530	Alb 5459	9.0	K0	23 36	+ 3 29.4	0.532	180.0	Ci. 18	12.6	0.035	6.7		346	+32
499	148653	Be A 5909$_1$	7.79	K0	24 29	+18 37.4	0.508	320.1	Ci. 18	11.3	0.080	7.3	−36.	4	+38
500		Be A 5909$_2$	7.79	K0	24 29	+18 37.4	0.508	320.1	Ci. 18	11.3	0.080	7.3	−36.	4	+38
501		BD−12° 4523	9.5	Ma	24 45	−12 24.4	1.24	180.	A.N. **211**, 223	15.0				332	+24
502	148704	Cordoba 22345	7.49	G5	24 47	−38 47.2	0.563	234.1	U.C. 34	11.3				310	+ 7
503			*10.0*		25 14	+44 55.0	0.750	199.7	Finn. Acad.	14.4				38	+43
504*	148808	CPD−40° 7356	10.10	A0	25 32	−40 6.0	1.054	312.3	U.C. 19	15.2				309	+ 6
505	148816	Alb 5471	7.45	G0	25 33	+ 4 26.1	1.450	198.4	Ci 18	13.2	0.025	4.4	−52.0	347	+33
506	149661	12 *Ophiuchi*	5.87	K0	31 6	− 2 6.7	0.543	126.1	P.G.C.	9.6	0.077	5.8		342	+28
507	149957	Lei 5865	9.5	K5	32 55	+31 18.7	0.59	144.2	Ci. 18	13.4	0.060	8.4		19	+40
508	150680	*ζ Herculis* A	3.00	G0	37 31	+31 47.0	0.604	309.7	P.G.C.	6.9	0.116	3.3	−70.	20	+39
509		*ζ Herculis* B	6.7		37 31	+31 47.0	0.604	309.7	P.G.C.	10.6	0.116	7.0		20	+39
510	151541	Chri 2530	7.56	G5	42 51	+68 16.5	0.509	327.8	Ci. 18	11.1	0.043	5.8	+ 7.	67	+36
511*	151680	*ε Scorpii*	2.36	K0	43 41	−34 6.7	0.668	247.2	P.G.C.	6.5	-0.057		− 2.0	316	+ 7
512	152391	Nic 4232	6.78	G5	47 56	+ 0 10.9	1.664	206.6	Ci. 18	12.9	0.088	6.5	+41.	346	+25
513*		Comp to W-Ott 5811	*11.*	M	49 34	− 8 8.3	1.234	224.0	Ci. 18+Heid.	16.9	0.150	12.3		339	+20
514*	152751	W-Ott 5811	9.2	Md	50 8	− 8 9.1	1.234	224.0	Ci. 18	14.7	0.150	10.1		339	+20
515		BD+25°3173	9.4	Ma	54 4	+25 54.9	0.52	188.0	M.N. **72**, 65	13.0				13	+34
516	154345	Bo 10912	6.74	G0	59 47	+47 12.0	0.856	8.5	Ci. 18	11.4	0.091	6.5	−46.	41	+36
517*	154363	Strb 5817	7.90	K5	59 51	− 4 53.8	1.465	219.8	Ci. 18	13.7	0.072	7.2	+27.5	342	+20
518*		Strb 5819	9.3	K5	17 0 2	− 4 55.3	1.465	219.8	Ci. 18+Heid.	15.1	0.072	8.6		342	+20
519			9.7		3 7	−46 23.0	0.77	180.0	U.C. 34	14.1				309	− 4
520*			*11.4*		4 40	−76 1.1	1.592	48.7	U.C. 19	17.6				284	−21
521		Wolf 648	*14.*		6 4	+39 18.0	0.80	180.	Heid.	18.6				31	+35
522	155918	Cordoba 23312	6.98	G0	9 11	−75 14.1	0.982	265.2	U.C. 19	12.0				284	−20
523	155876	Bo 11026	9.6	K5	9 12	+45 49.7	1.590	171.6	Finn. Acad.	15.6				39	+36
524*	155885	36$_1$ *Ophiuchi* A$_1$	5.33	K0	9 12	−26 27.4	1.242	202.5	P.G.C.	10.8	0.174	6.5	− 5.	327	+ 7
525*	155886	36$_2$ *Ophiuchi* A$_2$	5.29	K0	9 12	−26 27.3	1.222	203.7	P.G.C.	10.7	0.174	6.5	− 5.	327	+ 7
526		BD+42° 2810	9.6	Ma	9 56	+42 27.5	1.061	247.0	Ci. 18+Finn. Acad.	14.7	0.069	8.7		35	+35
527*	156026	30 *Scorpii*	6.66	K2	10 4	−26 24.1	1.223	203.6	P.G.C.	12.1	0.174	7.9	− 8.	327	+ 7
528*			*11.4*		11 11	−75 52.4	1.497	241.7	U.C. 19	17.5				284	−21
529*	156274	41 *Arae*	5.58	K0	11 28	−46 31.9	0.969	77.7	P.G.C.	10.5	0.175	6.8		310	− 6
530*		Comp to 41 *Arae*	8.4		11 28	−46 31.9	0.969	77.7	P.G.C.	13.3	0.175	9.6		310	− 6
531*	156384	142 *Scorpii* A	5.89	K2	12 9	−34 52.7	1.199	98.6	P.G.C.	10.3	0.170	7.1	− 4.	320	+ 1
532*		142 *Scorpii* B	8.1		12 9	−34 52.7	1.199	98.6	P.G.C.	13.5	0.170	9.3		320	+ 1
533*		142 *Scorpii* C	10.0		12 9	−34 52.2	1.199	98.6	P.G.C.	15.4	0.170	11.2		320	+ 1
534*		Wolf 672	*13.*		13 35	+ 2 3.8	0.56	230.	Heid.	16.9				351	+21
535		Wolf 692	*13.5*		16 28	+36 46.3	0.62	188.	Heid.	17.6				28	+32
536			*10.6*		16 40	+41 50.3	0.876	161.0	Finn. Acad.	15.3				34	+33
537	157214	72 w *Herculis*	5.36	G0	16 55	+32 35.8	1.061	173.2	P.G.C.	10.5	0.089	5.1	−78.4	23	+31
538	157387	Cordoba 23548	7.6	F5	17 47	−41 24.5	0.589	83.2	U.C. 19	11.5				304	− 3
539	157881	Alb 5766	7.9	K5	20 47	+ 2 14.0	1.315	207.2	Ci. 18	13.5	0.146	8.7	−27.8	352	+20
540	158633	Chri. 2655	6.31	K0	25 18	+67 23.4	0.536	271.3	Ci. 18	9.9	0.081	5.9	−38.3	64	+32
541*	159482	Lpz II 7907	8.5	G	29 53	+ 6 4.2	0.623	310.7	Ci. 18	12.5	0.010	3.5	−148.	358	+20
542			9.1	Ma	33 24	+18 37.4	1.39	42.6	Ci. 18	14.8	0.134	9.7		9	+23
543	160269	26 *Draconis* A	5.31	F8	33 57	+61 57.1	0.563	154.6	P.G.C.	9.1	0.079	4.8	−11.8	58	+32
544		26 *Draconis* B	10.6		33 57	+61 57.1	0.563	154.6	P.G.C.	14.4	0.079	10.1		58	+32
545		26 *Draconis* C	10.5	Ma	34 30	+61 45.	0.575	155.9	A.S.P. **23**, 319	14.3	0.079	10.0		58	+32
546			*11.5*		35 10	−58 4.0	0.554	246.1	U.C. 48	15.3				30.2	−15
547	160693	Lund 7228	8.6	G0	36 15	+37 15.6	0.945	210.7	Ci. 18	13.5				30	+29
548*		Chri 2710	9.5	Mb	37 0	+68 25.8	1.334	196.4	Ci. 18	15.1	0.268	11.6		65	+31
549			*11.*		38 15	−57 13.9	1.771	216.8	U.C. 48	17.6				303	−15
550	161198	Be B 6102	7.45	K0	39 2	+21 40.3	0.623	189.9	Ci. 18	11.4	0.053	6.0		13	+23

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
551		BD+43° 2796	9^m5	Ma	$17^h40^m55^s$	+43°26′.3	0″616	180.1	Finn. Acad.	13^m5				38°	+29°
552		*μ Herculis* B	9.5	Mb	42 31	+27 46.7	0.817	203.4	P.G.C.	14.1	0.116	9.8		20	+24
553		*μ Herculis* C	9.8	Mb	42 31	+27 46.7	0.817	203.4	P.G.C.	14.4	0.116	10.1		20	+24
554	161797	*μ Herculis* A	3.48	G5	42 33	+27 46.7	0.817	203.4	P.G.C.	8.1	0.116	3.8	−15.7	20	+24
555	161848	Alb 5924	8.96	K0	42 50	+ 4 58.9	0.70	250.7	Ci. 18	13.2				358	+16
556		Barnard's Star	9.67	Mb	52 54	+ 4 25.2	10.252	355.9	A.S.P. **34**, 126	19.8	0.526	13.3	−117.	358	+13
557	164922	Cbr E 8618	7.10	K0	58 27	+26 19.7	0.72	148.3	Ci. 18	11.4	0.084	6.7		20	+20
558	165341	70_1 *Ophiuchi*	4.28	K0	18 0 24	+ 2 31.4	1.131	167.1	P.G.C.	9.6	0.192	5.7	− 7.	357	+10
559		70_2 *Ophiuchi*	5.98	K5	0 24	+ 2 31.4	1.131	167.1	P.G.C.	11.3	0.192	7.4	− 7.	357	+10
560*		Washington 6520	9.2	B	0 31	−16 41.8	0.55	96.	A.G. Washington	13.0				341	+ 1
561		Wolf 816	*12.5*		4 59	+20 1.1	0.53	220.0	Heid.	16.4				15	+17
562	166620	Lund 7524	6.40	K0	6 19	+38 27.1	0.58	215.9	Ci. 18	10.2	0.094	6.3	−17.7	32	+23
563		Wolf 830	*14.5*		9 25	+21 4.4	0.50	210.	Heid.	18.0				16	+17
564		Wolf 834	*13.*		11 17	+20 29.1	1.00	210.	Heid.	18.2				15	+16
565		Wolf 843	*13.5*		13 40	+23 15.6	0.53	260.	Heid.	17.2				18	+17
566*	168723	*η Serpentis*	3.42	K0	16 8	− 2 55.5	0.898	218.9	P.G.C.	8.0	0.070	2.6	+ 9.6	355	+ 5
567*	169822	Lpz II 8491	7.9	G5	21 25	+ 8 44.0	0.512	204.5	Ci. 18	11.5	0.029	5.2		5	+ 9
568*	169889	Lpz II 8497	8.5	G5	21 36	+ 8 34.2	0.512	204.5	A.J. **32**, 173	12.1	0.029	5.8		5	+ 9
569	170153	*χ Draconis*	3.69	F8	22 52	+72 41.4	0.638	125.3	P.G.C.	7.7	0.127	4.2	+32.4	70	+27
570		BD+45° 2743	9.5		32 22	+45 39.1	0.583	51.8	Finn. Acad.	13.3				41	+21
571		Wolf 851	*12.*		36 31	+ 0 52.2	1.90	170.	Heid.	18.7				0	+ 2
572		Lei 6797	8.8	K3	37 8	+31 27.7	0.82	176.4	Ci. 18	13.4	0.036	6.6		28	+14
573	173739	Hels 9945_1	8.76	Mb	41 40	+59 28.7	2.307	325.3	Ci. 18	15.6	0.292	11.1		56	+23
574	173740	Hels 9945_2	9.4	Mb	41 41	+59 28.3	2.307	325.3	Ci. 18	16.2	0.292	11.7		56	+23
575			*13.5*		43 42	−59 22.5	0.550	171.5	U.C. 48	17.3				304	−23
576		Be A 7030	9.0		44 28	+17 20.3	0.579	222.4	Ci. 18	13.2				16	+ 7
577	175224	CPD -56^0 9037	8.7	K5	49 12	−56 6.2	0.499	180.0	U.C. 48	12.2				308	−23
578	176029	BD+5° 3993	9.7	Ma	53 8	+ 5 48.5	1.247	189.9	Ci. 18	15.2	0.086	9.4		7	0
579		Be A 7153	9.5		56 22	+18 57.0	0.617	204.0	Ci. 18	13.6	0.017	5.7		18	+ 6
580	177095	BD−20° 5385	9.4	G0	58 3	−20 35.4	0.71	203.3	Ci. 18	13.7				343	−12
581	178126	Lpz II 9034	9.5	K0	19 2 14	+ 7 28.9	0.812	201.6	Ci. 18	14.1	0.048	7.9		9	0
582		17 *Lyrae* C	11.3	Ma	3 40	+32 21.	1.658	48.2	Bu.	17.4	0.121	11.7		31	+10
583		Wolf 1062	*11.2*		7 2	+ 2 43.9	2.09	90.	A.N. **212**, 167	18.2				6	− 5
584	179626	BD−0° 3676	9.3	G0	8 14	− 0 45.1	0.53	216.2	Ci. 18	12.9				2	− 6
585	179957	Bo 12729_1	6.84	G5	9 30	+49 40.0	0.629	344.0	P.G.C.	10.8	0.045	5.1	−40.	47	+17
586	179958	Bo 12729_2	6.62	G5	9 30	+49 40.1	0.654	343.1	P.G.C.	10.7	0.045	4.9	−40.	47	+17
587		Bo 12845	8.8		15 44	+41 28.1	0.659	174.8	Finn. Acad.	12.9				41	+12
588		CPD−45° 9704	9.1	F8	16 31	−45 15.3	0.809	185.3	U.C. 39	13.6				320	−24
589		31 b *Aquilae*	5.23	G5	20 12	+11 43.8	0.960	48.9	P.G.C.	10.1	0.070	4.4	−97.6	14	− 3
590		3 *Cygni*	6.17	F8	21 17	+24 43.9	0.658	196.4	P.G.C.	10.3	0.043	4.4	− 5.0	26	+ 3
591		Cord B 12795	7.04	G0	26 26	−28 12.7	0.742	175.3	P.G.C.	11.4	0.058	5.8		338	−21
592		BD+35° 3659 sf.	9.5		27 38	+35 57.4	0.56	184.	A.N. **207**, 171	13.2				36	+ 8
593		Hels 10565	6.70	K0	29 28	+58 23.0	0.664	233.4	Ci. 18	10.8	0.036	4.5	+12.	58	+17
594		Alb 6750	10.5	K5	29 39	+ 4 21.4	0.58	62.1	Ci. 18	14.3				9	− 8
595		Lei 7452	6.61	G0	29 44	+32 58.7	0.517	294.1	Ci. 18	10.2	0.042	4.7	−162.	33	+ 6
596		Wolf 1108	*12.*		32 30	+53 1.4	0.54	24.	A.N. **213**, 31	16.0				53	+14
597		*σ Draconis*	4.78	K0	32 33	+69 29.5	1.839	162.7	P.G.C.	11.1	0.182	6.1	+26.2	68	+21
598		*α Aquilae*	0.89	A5	45 54	+ 8 36.2	0.657	54.6	P.G.C.	5.0	0.214	2.5	−33.	14	−10
599		Harv II 7019	9.1	K5	51 46	−12 49.2	0.51	186.5	Ci. 18	12.6				356	−21
600		Wolf 1122	*11.*		53 5	+51 0.0	0.57	50.	A.N. **213**, 31	15.2				52	+11
601		Harv II 7042	7.64	G0	55 29	−12 31.2	0.504	223.4	Ci. 18	11.1				356	−21
602		Cordoba 27380	6.02	G5	55 32	−67 34.9	1.06	132.0	Ci. 18	11.1			−13.5	294	−32
603		Be A 7859	7.19	G5	58 0	+15 19.8	0.608	196.3	Ci. 18	11.1	0.060	6.1	+12.	22	− 9
604		*δ Pavonis*	3.64	G5	58 55	−66 26.2	1.626	134.8	P.G.C.	9.7			− 22.2	298	−32
605		Cbr E 10780	5.68	K0	59 31	+29 37.8	0.855	128.2	P.G.C.	10.4	0.056	4.4	−46.4	35	− 2

LIST OF STARS WHOSE ANNUAL PROPER MOTIONS ARE NOT LESS THAN 0″.50—*Continued*

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
606		15 *Sagittae*	$5^{m}89$	G0	$19^{h}59^{m}37^{s}$	+16°47′.9	0″.579	224°.5	P.G.C.	$9^{m}7$	0″.077	$5^{m}3$	+ 3.1	23	− 9
607		Be B 7450	7.20	K0	59 41	+23 5.0	1.369	228.7	Ci. 18	12.9	0.068	6.3	+12.	29	− 5
608		Wolf 1129	*13.*		20 1 58	+50 55.6	0.65	33.	A.N. **213**, 31	17.3				53	+10
609		27 b_1 *Cygni*	5.52	K0	2 39	+35 41.8	0.496	208.0	P.G.C.	9.0	0.053	4.1		42	+ 1
610		Wolf 1130	*11.*		2 45	+54 10.4	1.48	240.	A.N. **213**, 31	17.2				56	+11
611		279 *Sagittarii*	5.34	K5	4 38	−36 21.1	1.625	164.5	P.G.C.	11.4	0.190	6.7	−130.	333	−31
612		Be A 7995	7.26	K0	6 34	+15 52.8	0.578	313.6	Ci. 18	11.1	0.064	6.3	−50.	24	−10
613		Cordoba 27655	7.5	K5	6 45	−45 27.6	0.77	102.8	Ci. 18	12.1				321	−33
614		5 *Capricorni*	5.69	K0	9 3	−27 19.9	1.258	98.8	P.G.C.	11.2	0.040	3.7	−53.	343	−30
615		Kas 3463	9.3	K5	13 51	+76 55.2	0.495	9.2	Gr. Astr. 4+Ci. 18	12.8	0.072	8.6		77	+22
616			*12.*		14 28	−58 34.4	0.848	105.4	U.C. 48	16.7				306	−35
617		Chri 3163	6.08	F8	16 32	+66 31.9	0.557	58.2	P.G.C.	9.9	0.075	5.5	− 6.1	68	+16
618		BD−21° 5703	8.2	G0	17 42	−21 39.7	1.182	154.1	Ci. 18	13.6	0.019	4.6	−179.	351	−30
619		Cord B 13465	6.71	G0	21 32	−31 11.0	0.562	185.2	U.C. 19	10.5				339	−33
620		Wolf 1069	*14.5*		23 50	+58 13.8	0.51	5.	A.N. **212**, 303	18.0				61	+11
621		φ_2 *Pavonis*	5.30	F8	31 46	−60 53.0	0.645	152.8	P.G.C.	9.3			−30.6	304	−36
622		Lpz II 10245	9.01	F2	33 40	+ 5 18.0	0.90	261.6	M.W. 96	13.8				18	−21
623		Cord A 14339	6.33	G5	34 15	−24 8.4	0.658	46.4	Ci. 18	10.4	0.095	6.2		348	−34
624		Alb 7215	8.4	K5	34 33	+ 4 37.0	0.844	84.8	Ci. 18	13.0	0.074	7.7		17	−22
625		CPD−53° 9928	8.3	K5	34 58	−53 1.7	1.085	180.0	U.C. 48	13.5				312	−38
626		Kas 3569	7.62	G5	38 42	+75 13.9	0.632	32.8	Ci. 18	11.6	0.068	6.8		76	+20
627		Wolf 1084	*14.*		40 28	+54 56.7	1.87	21.	A.N. **212**, 303	20.5				59	+ 7
628			*9.4*	Ma	41 32	+44 7.7	0.504	58.5	Finn. Acad.	12.9				52	0
629*		η *Cephei*	3.59	K0	43 15	+61 27.0	0.826	6.2	P.G.C.	8.2	0.091	3.4	−87.0	65	+10
630		Wolf 891	*10.*		48 50	− 3 7.9	0.79	230.	Heid.	15.0				12	−29
631		Cordoba 28682	6.78	G5	50 28	−69 57.4	0.509	126.1	U.C. 19	10.3				291	−36
632		Cordoba 28703	6.64	G0	51 3	−44 29.2	1.138	209.7	Ci. 18	11.9			−16.0	323	−41
633		Hels 11731	8.6	Ma	51 16	+61 47.7	0.77	180.0	Ci. 18	13.0	0.150	9.5		65	+10
* 634		Wolf 896	*11.5*		51 22	−10 48.4	1.14	190.	Heid.	17.1	0.065	10.6		5	−33
635		Be C 2970	7.9	G5	52 22	+74 23.1	0.691	35.7	Ci. 18	12.1	0.034	5.6	−30.4	77	+17
636		Wolf 1100	*16.*		52 22	+56 9.7	0.56	222.	A.N. **212**, 303	19.6				61	+ 6
637		Wolf 901	*11.*		54 6	+ 3 10.6	1.11	160.	Heid.	16.6				20	−26
638*		CPD−34° 8843	8.7	F5	55 56	−34 26.6	1.311	172.4	U.C. 19	14.3				336	−41
639		Pots. Astr. 1214, 608	*9.7*	Md	56 12	+39 41.3	0.671	113.5	Finn. Acad.	13.8	0.089	9.4		49	− 5
640		Wolf 906	*11.*		56 42	− 6 42.0	0.53	190.	Heid.	15.0				11	−32
641		119_1 *Pavonis*	6.4	G0	58 54	−73 33.9	0.526	129.1	P.G.C.	10.0				287	−35
642		119_2 *Pavonis*	6.7	G0	58 54	−73 33.9	0.526	129.1	P.G.C.	10.3				287	−35
643			*14.*		59 48	−11 28.	0.55	107.	A.J. **31**, 96	17.2				5	−36
644		Lpz II 10563	8.9	K5	21 0 23	+ 6 41.2	0.553	173.8	Ci. 18	12.6	0.070	8.1		23	−27
645		61_1 *Cygni*	5.57	K5	2 25	+38 15.4	5.267	52.1	P.G.C.	14.2	0.310	8.1	−64.0	50	− 7
646		61_2 *Cygni*	6.28	K5	2 26	+38 15.2	5.153	53.5	P.G.C.	14.9	0.310	8.8	−64.0	50	− 7
647		Wolf 918	*11.*		3 43	−13 39.6	2.14	156.	Heid.	18.0				4	−38
648		Wolf 1106	*13.5*		5 36	+59 21.9	2.14	206.	A.N. **212**, 303	20.2				65	+ 7
649		Be A 8633	7.32	F5	7 21	+17 20.6	0.915	187.4	Ci. 18	12.1	0.029	4.6	−46.	34	−21
650		Be C 3000	8.8	K0	8 48	+73 18.0	0.518	221.7	Ci. 18	12.4	0.032	6.3		76	+17
651		Cordoba 29168	6.72	G0	10 47	−61 45.5	0.62	134.3	Ci. 18	10.7				300	−41
652*		Cordoba 29191	6.65	Ma	11 24	−39 15.2	3.532	250.6	Ci. 18	14.4	0.238	8.5	+13.	332	−44
653		Cord A 14707	6.50	G5	13 59	−26 45.9	0.665	237.9	Ci. 18	10.6	0.046	4.8	−43.	349	−43
654		Comp to Cord A 14707	9.9		13 59	−26 45.9	0.665	237.9	Ci. 18	14.0	0.046	8.2		349	−43
655		BD−20° 6185	9.2	K5	14 36	−20 15.3	0.764	193.8	Ci. 18	13.6				356	−42
656		γ *Pavonis*	4.30	F8	18 11	−65 49.1	0.815	5.8	P.G.C.	8.9			−31.3	295	−40
657		La Plata I 6966	8.6	G5	19 37	−56 33.6	0.721	75.3	U.C. 48	12.9				307	−44
658		Harv II 7623	9.4	K5	24 30	−12 56.4	1.052	104.5	Ci. 18	14.5	0.051	7.6	−90.	6	−41
659		Wolf 921	*13.5*		25 2	− 7 32.2	0.79	190.	Heid.	18.1				14	−40
660		Wolf 922	*10.9*		25 51	−10 13.7	1.22	89.	Heid.	16.7				10	−41

* Van Maanen, letter, 1928 Jan 13

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
661		Bo 15589	7^{m}87	G0	21^{h}26^{m} 0^{s}	+45°26′8	0″56	50°2	Ci. 18	11^{m}6	0″031	5.4	−83^{m}	57°	− 6°
662		CPD−50° 11576	8.1	G5	28 13	−50 14.0	0.59	259.2	Ci. 18	12.0				304	−46
663		Wolf 923	*13.5*		28 30	− 7 17.0	0.52	180.	Heid.	17.2				14	−40
664		Wolf 924	*13.*		29 25	− 7 27.8	0.56	150.	Heid.	16.9				14	−40
665		Wolf 926	*12.*		31 21	+51 5.0	0.52	70.	Heid.	15.9				62	− 1
666		Strb 7562	8.8	G5	33 1	− 2 44.7	0.566	242.5	Ci. 18	12.6				21	−39
667		BD+27° 4120	*10.3*	Mb	33 31	+27 16.5	0.505	90.0	M.N. **76**, 429	13.9				46	−19
668		Wolf 932	*14.5*		35 42	+47 12.2	0.51	220.	Heid.	18.0				61	− 4
669		CPD−58° 7893	8.6	Ma	39 24	−58 8.2	0.902	180.0	U.C. 48	13.4				302	−45
670		Be B 8366	9.1	K0	39 41	+24 53.2	0.65	215.7	Ci. 18	13.2	0.030	6.5		46	−22
671		Wolf 937	*11.5*		39 47	− 6 14.2	0.54	210.	Heid.	15.5				17	−42
672		Wolf 939	*12.5*		40 10	− 6 21.3	0.59	210.	Heid.	16.7				17	−42
673			*11.3*		41 1	+43 50.6	0.642	191.6	Finn. Acad.	15.7				59	− 8
674		Wolf 940	12.		41 28	− 0 37.4	0.93	122.	Heid.	17.1				23	−39
675		Wolf 944	13.5		43 3	+46 40.9	0.64	100.	Heid.	17.6				60	− 6
676		Wolf 945	*13.5*		44 8	+49 46.2	0.85	64.	Heid.	18.2				63	− 3
677		Lpz II 10955	8.61	K2	44 8	+ 5 15.5	0.54	95.3	Ci. 18	12.3				30	−36
678		Cordoba 29865	7.32	G0	45 38	−73 53.8	0.023	208.5	U.C. 19	10.9				284	−37
679			*10.1*	Ma	49 51	+41 19.0	0.530	135.9	Finn. Acad.	13.7				59	−10
680		Wolf 1143	10.8		50 47	+32 10.2	0.73	76.	A.N. **207**,171,**215**,357	15.1				53	−17
681		Cbr E 13062	6.83	F5	54 15	+29 20.7	0.545	225.1	Ci. 18	10.5	0.030	4.2	+ 7.	51	−21
682		*ε Indi*	4.74	K5	55 43	−57 11.8	4.705	123.4	P.G.C.	13.1	0.269	6.9	−38.7	304	−47
683		BD+9° 4955	*10.5*		55 58	+ 9 28.3	0.51	160.	Heid.	14.5				36	−36
684		Wolf 990	*14.5*		22 1 40	+ 2 56.7	0.66	130.	Heid.	18.6				31	−41
685		Cbr M 7464	7.9	K0	3 5	+52 39.1	0.629	237.9	Ci. 18	11.9	0.036	5.7	−35.6	67	− 3
686		Be B 8548	8.8		5 54	+22 18.4	0.592	265.7	Ci. 18	12 7	-0.002			48	−27
687		Wolf 1014	*11.*		7 37	+ 8 4.7	0.73	170.	Heid.	15.7				37	−38
688		BD+30° 4633	*10.*		7 39	+31 4.6	0.53	225.	A.N. **215**, 357	14.1				55	−21
689		32 *Gruis*	6.40	G0	8 32	−41 51.3	0 955	144.9	P.G.C.	11.3				325	−55
690		37 *Gruis*	5.44	G0	11 42	−54 6.5	0.792	149.3	P.G.C.	9.9			−14.0	306	−51
691		Lpz I 8899	6.94	G0	12 15	+12 23.8	0.853	83.1	Ci. 18	11.6	0.029	4.2	−31.	42	−36
692		*ν Indi*	5.42	G0	16 2	−72 44.5	1.449	118.6	P.G.C.	11.2	0.020	1.9	+25.6	285	−40
693		Wolf 1216	*12.5*		16 12	+29 16.7	0.75	185.	A.N. **215**, 357	17.2				55	−24
694		CPD−51° 11806	9.1	G5	16 17	−51 16.9	1.581	179.0	U.C. 19	15.1				310	−53
695*			10.5	M?	16 52	−57 42.5	0.642	68.6	U.C. 48	14.5				300	−50
696		Cord B 14541	7.76	K2	23 35	−30 30.4	0.87	166.2	Ci. 18	12.5				345	−59
697		Wolf 1037	*12.*		23 44	+ 5 20.0	1.57	160.	Heid.	17.2				38	−43
698*		Hels 13170	9.64	Mb	24 26	+57 11.8	0.87	246.9	Ci. 18	14.3	0.256	11.7		72	− 1
699*		Comp to Hels 13170	11.34	M?	24 26	+57 11.8	0.87	246.9	Ci. 18	16.0	0.256	13.4		72	− 1
700		CPD−59° 7808	*10.3*		25 58	−59 17.4	0.503	155.8	U.C. 48	13.8				297	−50
701		BD+53° 2911	9.5		28 43	+53 16.1	1.482	87.7	Mem. Spett. **2** a **1**, 95	15.7	0.039	7.5		70	− 4
702		La Plata I 7174	7.8	G0	29 46	−55 7.3	0.514	114.5	U.C. 48	11.3				302	−52
703			*12.5*		31 22	−65 54.3	0.892	102.	U.C. 53	17.1				290	−47
704		BD+1° 4637	10.3	F0	33 52	+ 2 0.2	0.55	99.5	A.J. **12**, 25	14.0	0.009	5.1		40	−46
705		*ξ Pegasi*	4.31	F5	41 42	+11 39.6	0.545	155.5	P.G.C.	8.0	0.061	3.2	− 5.3	48	−41
706		Comp *ξ Pegasi*	12.		41 42	+11 39.6	0.545	155.5	P.G.C.	15.7	0.061	10.9		48	−41
707		BD+43° 4305	9.5	Md	42 31	+43 49.2	0.858	237.4	Finn. Acad.	14.2				69	−14
708		*σ Pegasi*	5.30	F5	47 20	+ 9 18.2	0.516	85.2	P.G.C.	8.9	0.042	3.4	+13.4	48	−43
709		W. Ott 8161	8.7		50 33	− 8 21.3	0.536	95.9	Beob. Erg. Berl. 10	12.3				32	−58
710		Cord A 15480	7.6	K5	55 0	−23 3.8	0.899	272.0	Ci. 18	12.4	0.079	7.1		2	−65
711		Chri 3703	8.6	K0	55 9	+68 29.2	0.66	62.0	Ci. 18	12.7	0.028	5.8		81	+ 8
712			*12.5*		55 31	−55 2.0	0.740	129.0	U.C. 48	16.6				297	−56
713*		Cordoba 31353	7.44	Ma	59 25	−36 25.7	6.900	79.3	Ci. 18	16.6	0.282	9.7	+12.	333	−66
714		Chri 3719	7.50	G0	23 1 10	+67 52.4	0.615	75.4	Ci. 18	11.4	0.055	6.2	−21.	80	+ 6
715		Strb 7985	8.3	K2	3 58	− 2 48.0	0.587	98.5	Ci. 18	12.1	0.044	6.5		41	−56

LIST OF STARS WHOSE ANNUAL PROPER MOTIONS ARE NOT LESS THAN 0″50—*Concluded*

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
716		Cordoba 31496	6ᵐ24	G0	23ʰ7ᵐ57ˢ	−63°13′9	0″62	132°4	Ci. 18	10ᵐ2				287°	−51°
717		Hels 13841	5.65	K2	8 28	+56 37.0	2.099	81.8	P.G.C.	12.2	0.177	6.9	−20.4	78	− 5
718		W. Ott 8247	9.4	G2	8 52	− 9 28.5	0.557	94.7	P.G.C.	13.1	0.020	5.9		35	−62
719		W. Ott 8248	8.3	G0	8 52	− 9 28.1	0.557	95.5	P.G.C.	12.0	0.020	4.8		35	−62
720*		CPD−67° 3959	9.2	K0	11 1	−67 28.3	0.502	139.2	U.C. 19	12.7				283	−47
721*		Washington 8612$_1$	8.7		11 55	−14 21.8	1.301	202.1	Ci. 18	14.3	0.030	6.1		26	−65
722*		Washington 8612$_2$	8.3	F8	11 55	−14 21.8	1.301	202.1	Ci. 18	13.9	0.030	5.7	− 5.5	26	−65
723		γ *Piscium*	3.85	K0	11 59	+ 2 44.1	0.752	88.5	P.G.C.	8.2	0.022	0.5	−12.7	50	−53
724		Cbr E 14030	8.8	K	14 59	+28 19.4	0.707	95.9	Ci. 18+M.N. **71**, 584	13.0	0.063	7.8		68	−30
725		Bo 17689	7.55	G5	16 46	+43 32.6	0.671	70.4	Ci. 18	11.6	0.052	6.2	+ 2.	74	−17
726		Wolf 1038	*11.5*		20 7	+ 0 25.1	0.67	135.	Heid.	15.9				52	−46
727		Oxf Astr+28° 68304	*11.6*		20 57	+28 39.3	0.588	126.5	M.N. **71**, 584	15.7				69	−31
728		Hels 14122	6.85	K0	26 31	+58 36.6	1.06	85.1	Ci. 18	12.0	0.062	5.8	−24.7	80	− 3
729		Wolf 1039	*11.*	Ma	29 2	− 0 20.7	1.44	230.	Heid.	17.0	0.059	9.9		55	−58
730		Lei 10006	6.72	G0	30 27	+30 27.4	0.589	64.8	Ci. 18	10.6				72	−30
731			*10.8*	Ma	30 45	+41 24.6	0.718	76.5	Finn. Acad.	15.1				76	−19
732		Be A 9622	8.0	G5	30 59	+17 53.0	0.702	73.8	Ci. 18	12.2	0.035	5.7		67	−41
733		Wolf 1040	*13.*		31 37	+ 0 36.8	1.23	90.	Heid.	18.6				56	−58
734		Cordoba 31974	6.7	K0	33 42	−73 15.3	0.76	171.1	Ci. 18	11.1				277	−43
735		ι*Piscium*	4.28	F8	34 48	+ 5 5.1	0.575	139.6	P.G.C.	8.1	0.099	4.3	+ 5.6	60	−53
736		BD−8° 6177	9.7	G0	38 20	− 8 26.6	0.64	105.	Heid.	13.7				50	−66
737		Hels 14297	7.02	G0	38 32	+57 30.7	0.610	38.2	Ci. 18	10.9	0.023	3.8	−68.	81	− 5
738		Cbr E 14250	8.9	K0	40 1	+29 0.4	0.91	87.5	Ci. 18	13.7	0.018	5.2		74	−32
739		Cordoba 32117	7.51	A0	41 15	−42 6.8	0.88	165.3	Ci. 18	12.2				306	−70
740		Alb 8164	8.7	Ma	43 59	+ 1 52.3	1.393	134.3	Ci. 18	14.4	0.183	10.0		62	−57
741		Alb 8170	8.4	G5	44 56	+ 2 19.0	0.499	69.7	Ci. 18	11.9	0.023	5.2		62	−56
742		Cbr E 14346	7.30	G5	49 55	+28 4.6	0.573	88.0	Ci. 18	11.1	0.055	6.0		76	−33
743		Bo 18330	9.2	Ma	53 32	+46 10.4	0.64	90.0	Ci. 18	13.2	0.066	8.3		81	−16
744		BD−20° 6684	7.45	K0	54 17	−20 35.0	0.608	121.2	Ci. 18	11.4	0.046	5.7		26	−77
745		85 *Pegasi*	5.85	G0	56 57	+26 33.2	1.291	139.7	P.G.C.	11.4	0.101	5.8	−34.	78	−35
746		Comp to 85 *Pegasi*	11.		56 57	+26 33.2	1.291	139.7	P.G.C.	16.6	0.101	11.0		78	−35
747		Cordoba 32416	8.3	Ma	59 31	−37 51.0	6.112	112.7	Ci. 18	17.2	0.191	9.7	+26.	308	−76
748		Lei 10226	6.23	G0	59 39	+34 6.0	0.766	83.0	Ci. 18	10.6	0.040	4.2	+ 3.9	79	−28
749*			10.2	Ma	59 54	+45 14.0	0.856	100.2	Finn. Acad.	14.9	0.101	10.2		82	−17

Remarks on the Catalogue

No.

2 Not confirmed by C.P.D. (U.C. 19).

11 Groomb. 34 = Lal. 248.

22 The spectrum seems to have been derived from measures of effective wave-length (*Astr. Nach.*, **213**, 49, 1921; *cf. Publ. A.S.P.*, **34**, 132, 1922).

35 The spectral class was estimated from a spectrogram with dispersion of only 2 m.m. from H_β to K. Except the companion to *Procyon* and *Proxima Centauri*, the faintest absolute magnitude known.

51 Pickering's faint proper-motion star (H.C. 96).

75 Wolf (l.c.) gives the spectral class from effective wave-lengths as K1.

82 Data kindly communicated by Mr. van Biesbroeck. The photographic magnitude is 13.3, the proper motion mainly in α. Parallax would suggest Class M star.

102 Either a low-luminosity F star or a star with a large tangential velocity (400 km./sec. if the absolute magnitude has the normal value).

136 The star with the highest-known, well-established space velocity, 494 km./sec. (*Proc. Nat. Acad. Sci.*, **5**, 239, 1919.)

145 This star seems to have an enormous space velocity, or else the spectrum may be wrongly classified.

150 Spectral class K2 from effective wave-length.

152 On Plate I this star is represented with the enormous tangential velocity of 1050 km./sec.

174 Space velocity 320 km./sec.

188 Magnitude from Bernewitz (*Astr. Nach.*, **213**, 1, 1921).

207 Uncertain (U.C. 19).

213 This value of the parallax gives the star a space velocity of 520 km./sec.

233 The measured parallax (Flint) is −0″.068. The radial velocity suggests this star is a dwarf; thus a parallax of 0″.05 may be expected.

245 248 As the radial velocity of ι *Ursae Majoris* is not well determined, it is quite probable that these stars are moving together, for their proper motions and parallaxes are very nearly identical. There is remote possibility that ρ_1 *Cancri* also belongs to this system. The proper motions are all directed toward the apex of Drift I.

265 Apparently an F giant with the space velocity of almost 1000 km./sec. A spectrographic parallax of this star is not known.

287 Lal. 21185.

288 Lal. 21258.

298 Announced by Kobold as belonging to the α *Centauri* system (*Astr. Nach.*, **212**, 31, 1921); its distance from α *Centauri* is 0.95 parsec, and the values of μ and p make a physical connection improbable.

302 The invisible component of ξ *Ursae Majoris*. (*cf.* Nörlund, *Astr. Nach.*, **170**, 117, 1905; Wright, *Ap. Jour.*, **12**, 254, 1900; Hertzsprung, *Astr. Nach.*, **208**, 111, 1918.

328 Groombridge 1830.

357 Spectrographic parallax 0″.046, $M=4^{m}.2$; all trigonometric values, however, point to its being a giant.

363 Space velocity 405 km./sec.; Mt. Wilson has F3 for the spectrum.

391 Probably an F8 star of low luminosity; normal absolute magnitude would give it a tangential velocity of 600 km./sec.

395 Proper motion uncertain, depends on W-Z and C.P.D.

428 Innes's distant companion to α *Centauri*.

452 Space velocity 440 km./sec. Mt. Wilson calls the spectrum F4.

457 458 The parallax values taken for each star separately would give as the means 0″.017 and 0″.050 resp. There can be no reasonable doubt, however, that both stars move closely together in space. The space velocity derived from $\pi=$ 0″.029 is about 670 km./sec. Both stars are faint for their spectral class.

478 and 504 Probably two white dwarfs (*cf. Publ. A.S.P.*, **34**, 132, 1922).

480 481 Possibly community of motion with γ *Serpentis*.

511 ε *Scorpii* has a measured parallax of −0″.057; a value of 0″.03 is expected if it is a normal giant.

513 514 These two pairs were both announced by Wolf to have a proper motion of 1″.25 in 222°.

517 518 The very different values of the parallaxes, however, make any physical connection between the two highly improbable.

520 and 528 Doubtful, not confirmed by C.P.D.

524–525–527–529–530–531–532–533. These three multiple systems are situated close to each other in space; the proper motions, however, do not make a connection between them possible.

541 Space velocity 330 km./sec. Mt. Wilson calls spectrum F6. It is Bu 8068 C. The principal star is of the same absolute magnitude but has a proper motion of only 0″.070.

548 A−Oe 17415.

560 The proper motion was derived by comparing the two places Washington 6520 and Mü. I 15333, with a difference in epoch of almost 50 years. If the proper motion is correct it is a remarkable star as the spectrum appears to be of Class B.

566 A K giant of low absolute magnitude.

567 568 For the proper motion, a mean value, the same for both stars, was derived from a combination of the data in Ci. 18 and *Astr. Jour.*, **32**, 173, 1920.

629 A K giant of low absolute magnitude and high velocity.

638 Another F star with high velocity or low absolute magnitude.

652 Lac. 8760.

695 C.D. −57° 8545, $9^{m}.9$. Innes gives the photographic magnitude as 12; it is therefore probably an M star.

698 699 Krüger 60. Magnitudes from Hertzsprung (*Astr. Nach.*, **208**, 267, 1918). Faint component has same effective wave-length (*Ap. Jour.*, **42**, 111, 1915).

713 Lac. 9352.

720 Proper motion probably identical with that of $23^{h}\,11^{m}\,14^{s}$, −67° 27′.2 (1900) vis. 0″.455, 165°.4. In that case the star should be cancelled in our list, as the mean of the two proper motions would fall considerably below 0″.500.

721 722 A close pair with a tangential velocity of over 200, and radial velocity of only 6 km./sec.

749 Companion to No. 3.

To the list will probably have to be added the two stars B.D.+57° 2514 and +56° 2779, both of which are dwarfs according to Lindblad (*Universitets Arsskrift*, Upsala, 1920). From the absolute magnitudes proper motions 0″.6 and 0″.8 resp. may be expected.

The following changes have been effected when correcting the proof sheets; the statistical discussion in the second part of the paper, however, is based on the old values.

Nos. 3 and 4 : magnitudes changed from 8^{m}62, 8^{m}62 to 9^{m}3, 9^{m}4
spectral class changed from K2, K2 to K7, K8
H changed from 13.3, 13.3 to 14.0, 14.1
M changed from 8.6, 8.7 to 9.3, 9.5

158 : spectral class changed from K2 to Ma

545 : magnitude changed from *11.8* to 10.5
H changed from 14.8 to 14.3
M changed from 10.5 to 10.0

552 and 553 : magnitudes changed from 10.5, 11.0 to 9.5, 9.8
H changed from 15.1, 15.6 to 14.1, 14.4
M changed from 10.8, 11.3 to 9.8, 10.1

573 and 574 : spectral class changed from K5, Ma to Mb, Mb

With regard to No. 560, Washington 6520, it may be mentioned that a new meridian observation kindly secured by Dr. R. H. Tucker does not show an appreciable difference when compared with the Washington position. It is therefore very likely that the München place is in error, the more so as a correction of $+2^{s}$ to it will bring it in accordance with the later observations. Pocock (*Mon. Not. R.A.S.* **79** 49, 1918) showed that the proper motion given in A. G. Washington was incompatible with the Hyderabad position. Therefore this star whose spectrum belongs to Class B should be cancelled from our list.

The spectral classes for those stars which I found to be M dwarfs (*Publ. A.S.P.*, **34** Dec. 1922) have been inserted but have not been used in Part II.

Furthermore the following ten stars should be added to the list thus bringing the total number from 749 to 758 (one cancelled):

No.	H. D.	Name	Mag.	Sp.	R. A.	Dec.	μ	p	Source	H	π	M	V	l	b
145a	30501	CPD–50°637	7^{m}77	G5	4^{h}43^{m} 7^{s}	−50° 14′.7	0″.56	233°.0	Ci 18	11^{m}5				225°	−39°
235a	74000	Washington 3498	9.4	F5	8 36 11	−15 58.6	0.558	132.9	M.N. **79,** 49	13.1				208	16
276a		Washington 4149	9.0		10 16 30	−16 32.9	0.535	286.0	M.N. **79,** 49	12.6				226	34
395a		BD +47° 2072	*10.7*		13 31 16	+47 5.2	0.718	140.1	ms.v Rhijn	15.0				67	67
397a		Wolf 496	*11.*		39 12	+ 5 23.2	0.50	240.	Heid.	14.9				306	65
409a	121849	CPD–33°3546	8.4	G0	52 50	−33 30.3	0.59	235.9	Ci. 18	12.3				287	28
412a		Wolf 530	*15.*		58 35	+20 19.5	0.51	170.	Heid.	18.5				342	72
582a		Washington 77129	9.0		19 6 22	−15 58.7	0.836	140.6	M.N. **79,** 49	13.6				348	−12
611a		Comp to 279 Sagitt	11.3		20 4 38	−36 21.1	1.625	164.5	Boss Bu	17.4	0.190	12.7		333	−31
743a		Washington 8808	8.7		23 54 12	−17 30.0	1.139	90.0	M.N. **79,** 49	14.0				38	74

II. DISCUSSION OF THE MATERIAL COLLECTED

Inasmuch as stars with proper motions exceeding a certain value can be regarded as representing the stars in a limited volume of space, it may be of interest to discuss statistically the material collected here, and to see how the fundamental laws of stellar astronomy hold for this particular group of stars. The representation of all the stars in a limited volume of space is, however, far from rigorous, as on account of the selection in accordance with apparent angular speed, undoubtedly many nearby, slow-moving stars (such as early-type stars like *α Piscis Austrini* and *α Lyrae*) have been omitted, and on the other hand a number of distant and rapid-moving objects have been included (37 *Phoenicis*, 33 *Virginis*). We must be careful therefore in drawing from our material any conclusions involving the velocities of the stars. The volume of space is certainly not limited by a spherical surface but by a surface extending unequally in different directions, on account of the solar and stream motions. In the mean, however, we may still regard this part of space as a sphere, the radius of which will have to be determined later on from statistical considerations.

1. Completeness of the Catalogue

The lists of Porter [5] and Kobold[6] contained a little over 300 stars with proper motions exceeding 0″.5 annually, double stars being counted as one. Van Maanen's[7] catalogue in which the components of double and multiple stars were counted separately included 531 such objects, whereas the present list has a total of 749. The increase is entirely due to the large number of proper motions determined by photographic methods; in fact, the number of new proper motions determined from meridian-circle observations does not exceed the number that was cancelled.

For the purpose of testing the completeness of the present catalogue, the numbers of stars between definite limits of apparent magnitude and proper motion have been counted; the magnitudes having first been reduced by means of Table I; the result is given in Table II.

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[5] *Astr. Jour.*, **12**, 25, 1892.

[6] *Bau des Fixsternsystems*, 1908.

[7] *Contributions Mt. Wilson Obs.*, Nos. 96 and 111.

TABLE II

	2″000	1″682	1″414	1″190	1″000	″841	″707	″595	.500
	3	–	–	2	–	–	–	2	–
$2^{\mathrm{m}}00$	1	–	–	–	–	–	1	1	2
3.00	–	1	1	2	1	2	7	3	3
4.00	4	1	1	2	2	1	5	1	7
5.00	5	1	6	7	3	4	8	5	14
6.00	6	–	1	5	8	6	12	20	29
7.00	2	1	4	4	3	9	13	20	38
8.00	7	2	3	9	3	18	17	28	55
9.00	7	3	6	12	5	13	13	18	40
10.00	5	1	1	3	4	4	8	9	17
11.00	4	3	3	4	7	4	8	8	15
12.00	2	3	2	2	3	3	5	9	10
13.00	–	–	2	4	5	3	4	6	11
14.00	–	2	–	–	–	1	4	1	5
15.00	–	–	1	–	–	–	–	–	1
16.00									

The incompleteness of the catalogue becomes at once conspicuous in the sharp drop in the total number below $9^{\mathrm{m}}0$. For a more detailed discussion a comparison has been made with the results of Kapteyn and Van Rhijn. From the data given by them in *Groningen Publications*, No. 30, Table 7, the probable number of stars between given limits of m and μ was computed for the whole sky. It may be mentioned, that their calculations are based on essentially the same material as that in the present list, but it has been made homogeneous over the whole sky. In Table III are given those computed and observed numbers.

It will be seen that the computed and observed numbers between $7^{\mathrm{m}}0$ and $8^{\mathrm{m}}0$ differ largely; this is partly due to the fact that in the present list several proper motions have been rejected, that were included in the material used by Kapteyn and Van Rhijn. It may further be due to the difference in magnitude scale adopted, as Kapteyn and Van Rhijn seem to have used, without reduction to the Harvard system, the magnitudes given in Van Maanen's catalogue. These are B.D. or C.P.D. magnitudes and may differ very materially from the Harvard values in individual cases. Taking account of this possibility, we come to the conclusion that our list is nearly complete down to $7^{\mathrm{m}}0$ and that not many stars are missing, that are brighter than $8^{\mathrm{m}}0$. (This statement does not apply to such stars for which at present the proper motions are known as 0″494 and which by a re-discussion of the observations might reach the value 0″496.)

TABLE III

Limits of Mag.	$\mu > 1''$		$\mu < 1''$	
	Kapteyn v. Rhijn	Luyten	Kapteyn v. Rhijn	Luyten
		41		66
$6^{\mathrm{m}}0$	20	20	57	67
7.0	19	14	146	80
8.0	37	24	212	116
9.0	81	33	158	83
10.0	48	12	240	37
11.0	101	21	404	35
12.0	(158)	12	(202)	27
13.0	(72)	17	(540)	24
14.0	(0)	3	(382)	12

Allowing for the relatively large uncertainties in the computed numbers of stars fainter than 12^{m}, owing to the extrapolation from a small area, we may roughly estimate the total number of stars with annual proper motions exceeding 0″500, as ranging from three to four thousand, or four to five times as many as are now known.

2. RELATION OF H AND M TO SPECTRAL CLASS

Diagrams representing the relation between absolute magnitude and spectral class have been given by Russell and others, and those for the relation between $H = m + 5 + 5 \log \mu$ and spectral class by Hertzsprung and by myself.[8]

It was noted then that there was but slight agreement between the two diagrams. The material for all those diagrams consisted of catalogue stars, *i.e.* it had an abundance of giants and did not do justice to the overwhelming majority of dwarfs in space. As has been said above, the stars treated here may be considered, in the mean, as the sole occupants of a sphere with the Sun as center, the radius of which sphere is as yet unknown but need not be known for the present.

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[8] *Lick Obs. Bull.*, **10**, 135, 1922.

Fig. 1 shows the relation between M and spectral class. Besides the dwarf branch, which is very definitely shown, a few yellow giants and the three well-known white dwarfs (o_2 *Eridani* B, Comp. to *Sirius*, and Van Maanen's F star) occur in this part of space. In a total number of 331 stars there are only 9 yellow giants or less than three per cent. The conditions here are, however, highly favorable for the giants, as the chance is very small that among the 400 stars for which no parallaxes are available, any more giants exist. Furthermore, if the total number of stars with $\mu > 0''.50$ should be between 3000 and 4000, as we have estimated, then these additional stars with their overwhelming majority of dwarfs will decrease still more the percentage of giants. On the other hand, the selection of stars on the basis of their high angular speed favors an exclusion of the giants as it is well known that the yellow giants generally have a much smaller linear velocity than the yellow dwarfs. Making a rough estimate, we may say, therefore, that in a total number of 3500 stars in the region of space here considered, there are probably not fewer than twenty and not more than forty yellow giants; that is fewer than 1%.

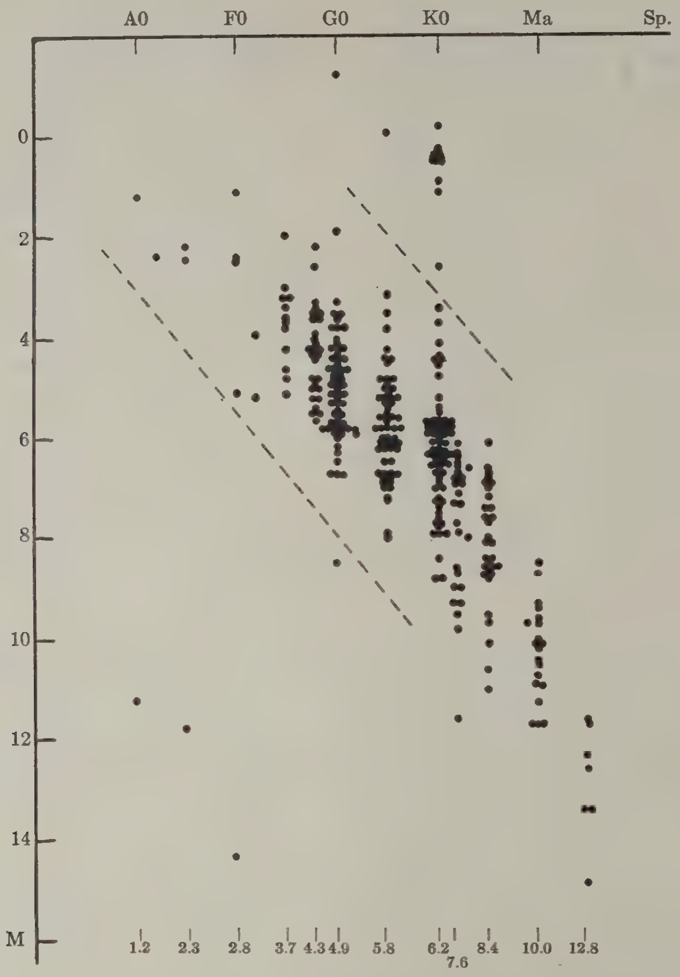

Fig. 1

Relation Between Absolute Magnitude and Spectral Class

Another fact to which it seems worth while to draw attention is the occurrence of two K-stars of an absolute magnitude intermediate between giants and dwarfs (*η Serpentis* and *η Cephei*) as compared with the entire lack of giants of Classes F and G. Considering this diagram alone, one would be apt to regard the K-giants simply as exceptionally bright specimens of K-dwarfs and would not directly connect them with the A-giants by means of intermediate stars of Classes F and G.

Let us now consider the relation between H=m+5 +5 log μ and spectral class which is shown in Fig. 2. This differs in many respects from Fig. 1, viz.: the yellow giants are much less clearly separated from the bulk of the stars and the white giants now appear brighter than the yellow. The reason is because the average linear speed of the early type stars is smaller than that of the late type stars. The fact that the linear speed reaches a maximum near spectral Class G seems to be responsible for the "dip" in H shortly before KO. (This is also due, in part, to the real difference in absolute magnitudes as will be seen from Fig. 1.) There is a comparatively large number of stars between Fo and G5 which lie considerably below the mean; these represent the few stars with abnormally high velocities, the existence of which is well known. This explanation fails, however, to account for the existence of the A and early F stars with exceedingly high values of H, for here the difference of 10^m between their values of H and the mean would point to a velocity one hundred times as large as the mean velocity. We are therefore more inclined to believe that these stars form real exceptions to the general relation between spectral class and absolute magnitude. This

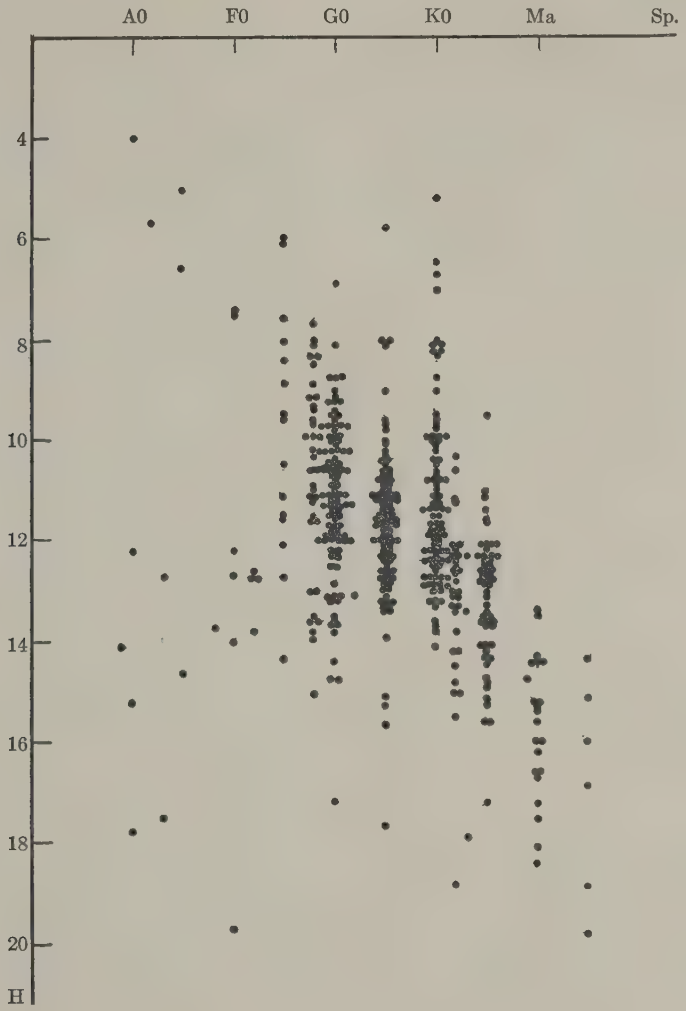

FIG. 2

RELATION BETWEEN H=m+5+5 log μ AND SPECTRAL CLASS view is supported by the fact that the few stars of this group for which parallaxes have been determined, *are* white dwarfs (o_2 *Eridani* B). This diagram seems therefore to strengthen the conclusion of Hertzsprung[9]:

"The absolutely-faint white stars seem to be even more frequent per unit volume of space than the absolutely bright yellow stars."

It has been shown that the assumption, that the absolute magnitude M can be expressed as a linear function of H is not at variance with the facts, if the constants of this relation are made dependent upon spectral class. At present we are dealing with a group of dwarfs belonging to different spectral classes and therefore we must not make the same assumption without again proving its validity. If a plot be made where each star is represented by rectangular coordinates $x=H$ and $y=M$, then the correlation between H and M would appear to be practically linear. The correlation constant, $r=\frac{V_{11}}{\sigma_1\sigma_2}$ is computed to be as high as 0.858 and accordingly when H is known, the most probable value of M is defined by:

$$\frac{M-m_2}{\sigma_2}=r\,\frac{H-m_1}{\sigma_1}$$

where $m_1=\frac{\Sigma H,}{n}$ $m_2=\frac{\Sigma M}{n}$ and $n=$ total number of stars.

In figures ($\sigma_1=\sigma_2$ in this case)

$$M-6.62=0.858\ (H-12.18)$$

Instead of this equation, however, the line of symmetry of the correlation table is to be preferred in this case. This line is defined by:

$$-H\sin\alpha+M\cos\alpha-l=o \text{ where}$$

$$l=\frac{\Sigma M\cdot\cos\alpha-\Sigma H\cdot\sin\alpha}{n}$$

$$\text{and }\tan 2\alpha=\frac{2\,\Sigma HM-\frac{2}{n}\Sigma H\,\Sigma M}{\Sigma H^2-\Sigma M^2-\frac{1}{n}\,\Sigma H\,\Sigma H+\frac{1}{n}\,\Sigma M\,\Sigma M}$$

From our data we find $\tan\alpha=1.002$ or with precision sufficient for the present, $\tan\alpha=1$ and accordingly: $M-H+5.58=o$ or

$$M=H-5\overset{\text{m}}{.}6 \tag{1}$$

From a given H, the absolute magnitude can thus be computed and hence an estimate of the parallax made[11]

The above equation also tells us something about the velocity of the stars, for if T be the tangential velocity, uncorrected for solar and stream motion and measured with 4.74 km./sec. as the unit, then we have the rigorous equation:

$$H=m+5+5\log\mu=m+5+5\log\pi+5\log T$$

$$\text{or } 5\log T=H-M=5.58$$

$$\underline{\mathbf{T}}=\mathbf{62.0}\text{ km./sec. }(\underline{\mathbf{T}}=\text{geometrical mean})$$

It is interesting to compare this with the result of Adams, Strömberg and Joy.[12]

From their Table IV (p. 10) we see that $\underline{\mathbf{T}}$ for dwarfs of all types together ranges from 30.9 to 66.5 km./sec., and is about 52 km./sec. for absolute magnitude 7, which is close to the mean 6.62 for the stars considered here. Remembering that we are dealing here with high-velocity stars, the agreement may be considered satisfactory. Later on (Section 8) we shall derive a still higher value for $\underline{\mathbf{T}}$.

As will be explained in section 4, it will be necessary to reduce all proper motions to a standard distance of 10 parsecs. This involves a knowledge of the parallaxes which is far from complete. The reduction to 10 parsecs could be made by means of the formula $M=H-5.58$, but this would automatically make all reduced proper motions equal to 62 km./sec. Therefore, as Lundmark[13] has shown that the correlation between M and Sp. is high enough[14] to allow a fair estimate of a star's parallax to be made by putting its absolute magnitude equal to the mean for its spectral class, these mean absolute magnitudes were derived from the data represented in Figure 1. It will be seen that these means, as entered in Fig. 1, are, for the stars from Fo to K5, lower than those obtained by Lundmark from more extensive material. This is not surprising as the stars in my list are characterized by high velocities, and it is well known that the mean velocities of the stars increase with the numbers expressing the absolute magnitudes. This has no effect on the M-stars as these stars, on account of their very low luminosity, all fall in the present list.

3. DERIVATION OF THE LUMINOSITY CURVE

Provided our stars can be regarded as the sole occupants of a certain volume of space, and provided also that, according to formula (1), the absolute magnitude and H differ only by a constant, the frequency-function of H will give us a fair idea about the "luminosity curve." This H-frequency curve is shown in Fig. 3, where the numbers of H for each half magnitude interval of the whole range from 4.0 (*Sirius*) to $22^{\mathrm{m}}.0$ (Wolf 611) are represented. It will be seen that a smooth curve drawn to represent these data differs from an error curve mainly by the excess on the faint side of the maximum. The H-luminosity-curve was computed by putting

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[9] *Bull. Astr. Inst. Neth.*, **1**, 21, 1922.

[10] It was assumed for simplicity's sake that the mean errors in H and M were equal. For the development of these formulae see *Mon. Not. R. A. S.*, **82**, (article in press), 1922.

[11] *Lick Obs. Bull.*, **10**, 153, 1922.

[12] *Contributions Mt. Wilson Obs.*, No. 210.

[13] *Publ. A. S. P.*, **34**, 147, 1922.

[14] In a combined paper we computed this correlation constant to be 0.73. *Mon. Not. R. A. S.*, **82** (article in press), 1922.

$$\log \Phi\ (H) = \alpha + \beta H + \gamma H^2, \text{ or}$$

$$\log \Phi\ (H) = a + c\ (H - H_0)^2$$

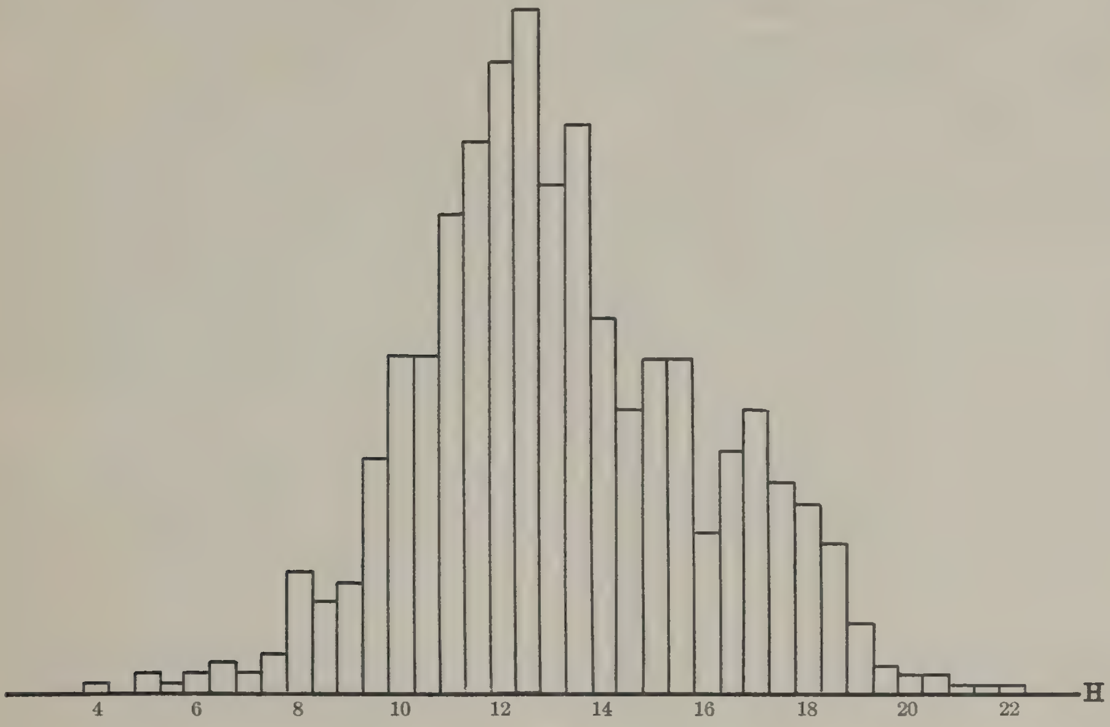

Fig. 3

Frequency Curve for H

To simplify the computation, the frequency of H was now taken over one and one-half magnitude intervals. A least-squares solution then yielded:

$$\log \Phi\ (H) = 2.143\ (\pm.050) - 0.0244\ (\pm.0100)\ (H\text{-}H_0)^2, \text{ or}$$

$$\Phi\ (H) = 139.0\ e^{-0.0244/\mathrm{mod.}\ (H\text{-}H_0)^2}$$

where $H_0 = 13^{\mathrm{m}}.20 \pm 0^{\mathrm{m}}.18$ and the errors given are mean errors. The agreement between the observed values of $\log \Phi\ (H)$ and those computed from the parabola is shown in Fig. 4, and may be regarded as very satisfactory. If we now make use of equation (1) by substituting $H = M + 5^{\mathrm{m}}.58$, we obtain for the real luminosity curve:

$$\Phi\ (M) = A \frac{h}{\sqrt{\pi}} e^{-h^2\ (M - M_0)^2}$$

where $\pi = 3.1416$, $A = 1080$, $M_0 = 7^{\mathrm{m}}.64$ and $h = 0.237$; and we have $\epsilon = 0.7071/h = 2^{\mathrm{m}}.98$.

This means that in our volume of space there are 1080 stars whose absolute magnitudes are distributed according to an error curve with $7^{\mathrm{m}}.64$ as mean value and $2^{\mathrm{m}}.98$ as mean error.

Kapteyn and Van Rhijn[15] find for the stars in the vicinity of the Sun

$$A = 0.0451^{16},\ M_0 = 7^{\mathrm{m}}.693,\ h = 0.2818,\ \epsilon = 2^{\mathrm{m}}.50$$

At first sight the agreement appears to be very satisfactory for M_0 and h, but the values of A cannot be compared as our limiting distance is not known. From the parallaxes in our list we find that the mean distance $\bar{\rho}$ of our stars is about 22.5 parsec (with considerable uncertainty). Assuming that the stars are uniformly distributed in space, the radius R of our limiting sphere becomes

$$R = \frac{4}{3}\bar{\rho} = 30 \text{ parsec.}$$

According to Kapteyn and Van Rhijn, a sphere of this size should contain a little over 5000 stars (each double star counted as only one star) with an admissable error at least 1000. We recall that from the counts of proper motions we estimated the total number to be between 3,000 and 4,000. The agreement is satisfactory, as the uncertainty in both estimates is considerable.

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[15] *Contributions Mt. Wilson Obs.*, No. 188.

[16] In this case the number of stars in one cubic parsec.

Knowing now that the 749 stars in our list do not form more than a fourth of the total number of stars with proper motions greater than $0''.50$, the agreement between the two luminosity curves begins to look rather doubtful. The missing stars are probably for the larger part below tenth magnitude (apparent), and we see from Table II that the mean H increases almost uniformly with m:

$$\text{for } m=4^m.5,\ \overline{H}=9^m.5;\ m=9^m.5,\ \overline{H}=14^m.2$$

This will result in the maximum of our Φ (H) curve being shifted toward larger values of H, an indication of which is given by the excess of large values of H close to the maximum. This involves a shift in M_0 and we therefore form the conclusion that the mean absolute magnitude of all stars is lower than $7^m.7$. How much the shift is we are as yet unable to say, although it may be considerable.

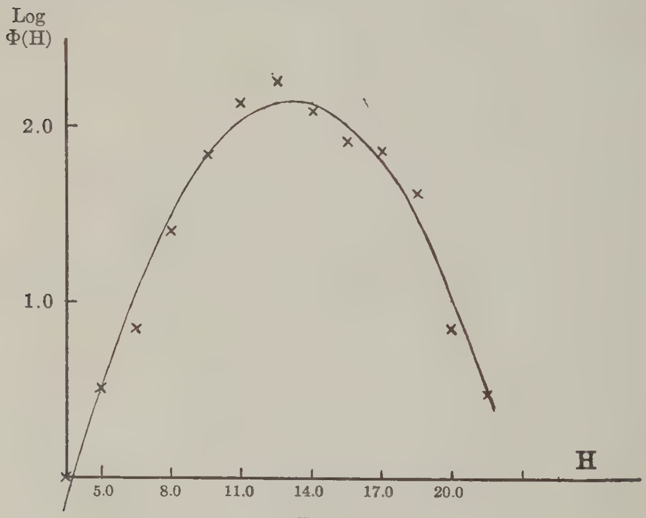

Fig. 4

Luminosity Curve for H

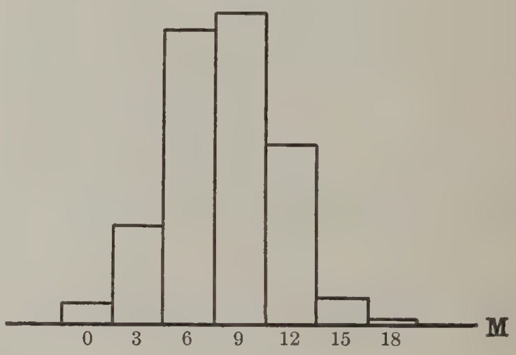

Fig. 5

Frequency of Absolute Magnitude for Stars Nearer Than 10 Parsec

It may be of interest to compare these results with those found from investigations of the nearby stars. From a compilation by Lundmark of all parallaxes larger than $0''.10$, from which I am allowed to quote some results, we can again derive the luminosity curve. In Fig. 5 this curve is shown representing all his 168 stars. The maxmum lies at about $7^m.5$, thus confirming again Kapteyn and Van Rhijn. Lundmark's list, however, cannot yet be complete, as according to Kapteyn and Van Rhijn's density we should expect 188 stars, when double stars are counted as one, or probably about 230 stars when the components of doubles are counted separately, to fall in this particular volume of space. As Lundmark's list contains more than two-thirds of this number, the shift in the maximum, when all these new and probably faint stars are included, will not be very large.

We may therefore predict that the real maximum of the luminosity curve will not lie very far from $+9^m.0$, or $+4^m.0$ on Kapteyn's scale.

4. Determination of the Solar Motion

As Bravais [16] method could not be used for determining the solar motion from this material, on account of the lack of the radial velocities, a solution was made following a procedure between Bravais's and Airy's methods. The proper motions were all reduced to the common distance of 10 parsecs, but as fewer than half the stars in the list have known parallaxes, another device had to be found for determining the distance. For this purpose a constant absolute magnitude was assumed for each determined spectral class and the mean values derived in section 2 were used. (We can assume, practically without exception, that all the stars for which no parallaxes are known, are dwarfs.) The values given under Fig. 1, are repeated here in Table IV.

The few yellow giants were reduced to 10 parsecs by supposing their absolute magnitude to be $+0^m.8$. For the stars without either known parallax or spectral class, this last quantity was "computed" from H. The H could not be used directly for determining the distance as this would automatically make all the proper motions when reduced to 10 parsecs, equal to 62 km./sec. The proper motions reduced to the distance of 10 parsecs will hereafter be called reduced proper motions or be denoted by μ_{10}.

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[16] *Journal de Liouville*, **8**, 1843.

TABLE IV

Sp.	$\overline{M}$	No. Stars
A0	$1\overset{m}{.}2$	1
A5	2.3	2
F0	2.8	4
F5	3.7	12
F8	4.3	28
G0	4.9	66
G5	5.8	57
K0	6.2	68
K2	7.6	24
K5	8.4	29
Ma	10.0	20
Mb	12.8	7

The sky was divided into the seventeen areas used by Eddington in his determination of the star streaming from the Boss stars.[17]

For convenience they are enumerated here again:

Area I: Polar Cap, Dec. +70° to +90°.

Areas II—VII: Dec. +36° to +70°, centres at R.A. 0^h, 4^h, 8^h, 12^h, 16^h, 20^h.

Areas VIII—XVII: Dec. 0° to +36°, centres at R. A. $1^h\ 12^m$, $3^h\ 36^m$, $6^h\ 0^m$, $8^h\ 24^m$, $10^h\ 48^m$, $13^h\ 12^m$, $15^h\ 36^m$, $18^h\ 0^m$, $20^h\ 24^m$, $22^h\ 48^m$.

Each region also takes in the antipodal region in the southern hemisphere, thus increasing the number of stars for the same region without unduly extending its area. The procedure of using areas distributed equidistantly in R. A. has the advantage (somewhat analogous to a Fourier-analysis), that in the normal equations for X, Y and Z, the mixed terms [ab], etc., disappear and each normal equation contains one variable only.

The mean reduced proper motion was then taken for each one of these areas, and equal weights were given to the areas in the solution. Owing to difficulties arising from some abnormally high reduced proper motions, three different methods of obtaining the mean μ_α and μ_δ for each area have been followed.

A. Strictly arithmetical means, $\mu_\alpha \cos\delta$ and μ_δ, were taken without rejecting any star.

B. All stars were rejected for which $\mu_{10} > 5''$.

C. The logarithmic mean of the reduced proper motions was taken for the following reason: The reduction of the original proper motions to the distance of 10 parsecs was made by means of a constant absolute magnitude for determined spectral class, and the errors are therefore distributed logarithmically. Stars that are fainter than the average for their spectral class (Kapteyn's Star) or for which too early a spectral class has been erroneously given, will therefore by their larger value of μ_{10} have a more considerable influence on the mean values of $\mu_\alpha \cos\delta$ and μ_δ than will stars for which the opposite holds. Accordingly there were computed the quantities:

$$(\log\ \mu_{10})\ \sin \mathrm{p} = \mu''_\alpha \text{ and } (\log \mu_{10}) \cos \mathrm{p} = \mu'_\delta.$$
$$\mu''_\alpha = \mu'_\alpha \cos\delta \text{ and p is the position angle of } \mu.$$

Next were found $\overline{\mu''_\alpha}$ and $\overline{\mu'_\delta}$ which were put equal to $(\log \nu) \sin \mathrm{q}$ and $(\log \nu) \cos \mathrm{q}$ respectively, thus giving

$$\tan \mathrm{q} = \overline{\mu''_\alpha}/\overline{\mu'_\delta} \text{ and } \log \nu = \sqrt{\overline{\mu''_\alpha}^{\,2} + \overline{\mu'_\delta}^{\,2}}$$

As the resulting proper motions in α and δ for the whole area were then taken.

$$\nu_\alpha \cos\delta = \nu \sin \mathrm{q},\ \nu_\delta = \nu \cos \mathrm{q}$$

Besides overcoming the influence of errors mentioned above, this procedure has the advantage that the real very-large proper motions can now be taken in without fear that they will influence the result too much. In fact, one might think that now the small proper motions have too much weight. We may therefore expect that h/ρ found by method C will be much smaller than that yielded by B, whereas A should give a still larger velocity. With regard to the position of the apex, we may anticipate that C gives a position intermediate to those found by B and A, and furthermore that the galactic latitude of apex A will be less than that of B, as the rapidly-moving stars which play such a prominent part in A, are moving more or less parallel to the galaxy. In all three solutions double and multiple stars have been treated as one.

The results, fully justifying these considerations, are given below in Table V where A_0 and D_0 are the R. A. and Dec. of the apex, h/ρ is the Sun's motion in seconds of arc as seen at a distance of 10 parsecs, and accordingly V_0 the velocity in km./sec. Errors given are mean errors.

TABLE V

	A	B	C
A_0	$294\overset{\circ}{.}2\pm5\overset{\circ}{.}7$	$285\overset{\circ}{.}1\pm3\overset{\circ}{.}3$	$289\overset{\circ}{.}3\pm4\overset{\circ}{.}0$
D_0	$+45.1\pm4.0$	$+36.8\pm2.9$	$+40.6\pm3.0$
$\frac{h}{\rho}$	$1\overset{\prime\prime}{.}256\pm\overset{\prime\prime}{.}0882$	$0\overset{\prime\prime}{.}895\pm\overset{\prime\prime}{.}0432$	$0\overset{\prime\prime}{.}620\pm.0324$
V_0	59.5 ± 4.2	42.5 ± 2.0	29.3 ± 1.5

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[17] *Mon. Not. R. A. S.*, **71**, 4, 1910

From a comparison of the A and B data we see that the inclusion of the rapidly-moving stars increases considerably the uncertainty in the linear velocity of the Sun. Furthermore, our fear that C would give too small a velocity is not realized, which means that the assignment of greater weight to the smaller proper motions does not even counterbalance the effect resulting from the selection of the original material.

5. DETERMINATION OF THE VERTICES

Stars of large proper motion generally afford good material for the determination of the vertices of star streaming, as they are subject to relatively small errors, especially in the directions of motion. In order to perform the solution for vertex, the reduced proper motions were corrected for solar motion. The apex and velocity of the Sun's motion as given by solution C were assumed to be closest to the truth, and corrections resulting from this motion to be applied to the reduced $\mu_\alpha \cos\delta$ and $\mu\delta$ are accordingly given by:

$$-v_\alpha = \sqrt{X^2+Y^2}\sin(\alpha+180^\circ - A_0)$$
$$-v_\delta = -Z\cos\delta + \sin\delta\,(-v_{\alpha+90^\circ}).$$

$-v_\alpha$ was read from a sine curve and $-v_\delta$ determined by a process of double interpolation. After the reduced proper motions had thus been freed from the effect of the solar motion, the directions of the vertices were found by applying the Bessel-Kobold method.[18] This method, although open to serious objections when applied to the determination of the solar motion, and bound to give erroneous results in that case, seems to be free from objections and extremely simple in the present case. For each of the seventeen regions mentioned before, the numbers of stars moving in a certain direction were plotted against these directions, and the direction corresponding to the maximum of this curve taken as the stream motion for that area. Usually there were two distinct maxima, which, theoretically, should be 180° apart. As this was not so, the mean of the two was taken after assigning weights proportional to the relative strength of the maxima. Following this the poles of these motions were computed. The vertex is then defined by the pole of that great circle on the celestial sphere, for which the sum of the perpendicular distances $\Sigma(\sin\Delta)^2$ of all these poles to the great circle is a minimum.

Kobold[19] has given a very elegant solution of this problem and finds that the coördinates of the vertex must satisfy the relations:

$$[yz]-[xz)\ \tan A_0+[xy]\ \tan\pi_0 \cot 2A_0-[x^2-y^2]\ \tan\pi_0=0.$$
$$\tfrac{1}{2}[xy]-[xz]\tan\pi_0+2\,[yz]\tan A_0\cot 2\pi_0-[z^2-y^2]\ \tan A_0=0.$$

where $\left.\begin{aligned} x&=\cos d\cos a\\ y&=\cos d\sin a\\ z&=\sin d\end{aligned}\right\}$ d and a = Dec. and R. A. of the center of the areas.

A_0, D_0 are the R. A. and Dec. of the vertex and π_0 is given by $\tan\pi_0=\sin A_0\cot D_0$.

A rather rapid approximate solution is given by the intersection point of the curves:

$$\tan\pi_0=\frac{[yz]-[xz]\tan A_0}{[x^2-y^2)-xy]\cot 2A_0},\ \text{and}$$

$$\tan A_0=\frac{\tfrac{1}{2}[xy]-[xz]\tan\pi_0}{[z^2-y^2]-2[yz]\cot 2\pi_0}$$

each of which corresponds to one of the equations given before. The final solution, however, was made in the following way: From inspection of a celestial sphere on which the seventeen poles were plotted an approximate position of the vertex was derived. Then values for A and D corresponding to six points surrounding this estimated vertex were used to derive six different values of $\Sigma(\sin\Delta)^2$. A paraboloid was computed by the equation

$$\Sigma(\sin\Delta)^2=a_1A^2+a_2D^2+2bAD+2c_1A+2c_2D+d.$$

The vertex is then given by $\Sigma(\sin\Delta)^2=$ Minimum,

or
$$a_1A+bD+c_1=0$$
$$bA+a_2D+c_2=0$$

from which we find:

$$A=104\overset{\circ}{.}6,\ D=+12\overset{\circ}{.}0,\ \Sigma(\sin\Delta)^2=0.572$$

Strangely enough, this does not satisfy Kobold's equations. A rigorous solution of these gives:

$$A=90\overset{\circ}{.}9,\ D=+17\overset{\circ}{.}0,\ \Sigma(\sin\Delta)^2=0.663$$

showing that it is not the point for which $\Sigma(\sin\Delta)^2$ is a minimum.

6. COMPARISON WITH RESULTS FOUND BY OTHER INVESTIGATORS

It is well known that the different determinations of the solar apex differ largely in declination. The declination of $+40\overset{\circ}{.}6$ found here can therefore at first be regarded as satisfactory. Boss[20] found from the proper motions of the G and K stars in his catalogue, D = +41°; Dyson and Thackeray[21] +37° for the F, G, and K stars in the Groombridge catalogue, in good agreement with my result.

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[18] *Nova Acta der Kais. Leop. Carol. Deutschen A Kad.*, **64**, *Astr. Nach.*, **132**, 305, 1893, **144**, 33, 1897, **150**, 257, 1899.

[19] *Astr. Nach.*, **132**, 313 H, 1893.

[20] *Astr. Jour.*, **26**, 187, 1911.

[21] *Mon. Not. R. A. S.* **65**, 428, 1905.

Apex determinations from radial velocities usually give a much lower value of D. Thus we have: Campbell[22] $D = +25\overset{\circ}{.}3$ from 1193 radial velocities, Strömberg[23] $+29\overset{\circ}{.}2$ from 1405 F-M stars, and Forbes[24] $+27°$ from 1900 stars.

For the large discordance between the higher values of D as derived from proper-motion data and the lower values as found from radial velocities, an explanation has been given by Kapteyn[25].

By adopting a correction of $+0\overset{''}{.}013 \cos \delta$ to the proper motions in declination in Boss's Catalogue Kapteyn succeeds in bringing the proper-motion apex down to the radial-velocity apex. (The Boss-Eddington result, based on all stars of Boss's catalogue, and adopted by Kapteyn as the most trustworthy, is $D = +35\overset{\circ}{.}2$).

At present we are dealing with stars of large proper motion and the correction resulting from Kapteyn's investigation will not be large. His formulae read:

$$A' = A, \quad \tan(D - D') = \frac{G \cos D}{h/\rho - G \sin D}$$

where $G = 0\overset{''}{.}013$, and in our case $h/\rho = h \cdot \overline{(1/\rho)} = 0\overset{''}{.}3875$. Accordingly $D - D' = +1\overset{\circ}{.}6$ (solution C.), which correction is only half the mean error in D. Kapteyn's correction does not explain, however, why the apex determined from late-type stars has a higher declination than when determined from early-type stars. An indication of where to look for explanation of our high declination may be found in the results of Dziewulski[26]. By application of Bravais's method, Dziewulski finds from 279 stars $D = +44°2$, but by rejecting all stars with "motus peculiares" larger than 80 km./sec, this is reduced to $+25\overset{\circ}{.}9$. The same difference, although less pronounced, is seen between the results of methods A and B (method B rejected all stars with $\mu_{10} > 5''$, or $T > 237$ km./sec.). At the same time the rejection of these high-velocity stars decreases in both Dziewulski's and my case the right ascension of the apex. Thus it appears plausible that our abnormally large value of A can find explanation along this line. Strömberg's[27] results seem to confirm this hypothesis, as for his F and G stars the R. A. of the apex increases steadily with the mean velocity. It is remarkable therefore that Raymond's[28] apex determination gives the same result for stars with both small and large proper motions, viz.:

Small: $(<0\overset{''}{.}20)$ $A = 269\overset{\circ}{.}0$ $D = +32\overset{\circ}{.}5$
Large: $(>0\overset{''}{.}20)$ $A = 269\overset{\circ}{.}3$ $D = +31\overset{\circ}{.}5$

If, following Campbell, we assume the true solar motion (i.e. with reference to the centroid of all stars) to be directed toward R. A. $= 270°$, $D = +30°$ with a velocity of 21.5 km./sec., then the results found here would indicate that this system of rapidly moving stars is not at rest with respect to the centroid of stars, but is moving with a velocity of 11.4 km./sec. towards the point $A = 163°$ and $D = 43°$.

The position of the vertex derived from our stars seems to agree very well with that found by other observers. A few of these are given below in Table VI, together with the material used.

TABLE VI

Investigator	Material Used	A	D	Ref.
Eddington	Boss stars	$94\overset{\circ}{.}2$	$+11\overset{\circ}{.}9$	29
Strömberg	Radial velocities	100	+34	30
Charlier	Boss stars	103	+19	31
Wicksell	Boss stars	93	+15	32
Meyering	Class K stars	86	+15	33
Comstock	Faint stars	87	+28	34
Dyson I	Stars with	88	+24	35
Dyson II	$0\overset{''}{.}2 < \mu < 0\overset{''}{.}8$	88	+21	
Beljawsky	Porter's p.m. stars	86	+24	36
Raymond I	Boss stars with	90	+19	37
Raymond II	$0\overset{''}{.}2 < \mu < 0\overset{''}{.}8$	92	+35	
Wirtz u. Hügeler	Wolf's p.m. stars	97	+15	38
Luyten	$\mu > 0\overset{''}{.}5$	104.6	+12.0	

It is surprising to see, when we compare our result with this table, that our stars with large proper motion give so much lower a declination for the vertex and a right ascension very different from all other results from large proper motions. The value of the declination accords very closely with Eddington's value. Dziewulski[39] computed the direction of the major axis of Schwarzschild's velocity ellipsoid for his 279 stars and found for the vertex $A = 102°$, $D = +15°$. As Dziewulski has used comparatively more nearby stars than Eddington, the higher declination could be expected when we consider Dyson's, Comstock's, and

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[22] *Lick Obs. Bull.*, **6**, 125, 1910.

[23] *Contributions Mt. Wilson Obs.*, No. 144.

[24] *Mon. Not. R. A. S.*, **82**, 174, 1922.

[25] *Bull. Astr. Inst. Neth.*, **1**, 69, 1922.

[26] "Ueber die Bestimmung der Sonnenbewegung nach der Bravaisschen Methode," *Extr. Bull. Acad. Sci. de Cracovie, classes Sc. Math. et. Nat.* A. juin, juillet, 1915.

[27] *Contributions Mt. Wilson Obs.*, No. 144.

[28] *Astr. Jour.* **30**, 191, 1917.

[29] *Mon. Not. R. A. S.*, **71**, 42, 1910.

[30] *Contributions Mt. Wilson Obs.*, No. 144.

[31] *Medd. frän Lund's Astr. Obs.*, série **2**, No. 9, p. 106.

[32] *Medd. frän Lund's Astr. Obs.*

[33] *On the systematic motions of the K-Stars*, Groningen, 1916.

[34] *Astr. Jour.*, **28**, 49, 1914.

[35] *Proceed. Roy. Soc. Edin.*, **28**, 231, 1908, **29**, 376, 1909.

[36] *Astr. Nach.*, **179**, 293, 1908.

[37] *Astr. Jour.*, **29**, 25, 1915, **30**, 191, 1917.

[38] *Sitz. Heid. Akad. Math. Nat. Kl.*, A, Jahrg. 1918, Abh. 9.

[39] *Acad. Crae.*, nov-déc, 1916. (See 26).

Beljawski's results, but the right ascension is larger than that found by any other investigator except Charlier. Kapteyn has also given corrections to the determinations of the apex of Drift I, resulting from the systematic error in $\mu\ \delta$, mentioned before, but as by using Kobold's method we do not obtain the quantity h/ρ, his corrections cannot be applied in our case. We can say, however, that as we are dealing here with stars of large proper motion, the correction may be expected to be small. It may be mentioned that the effect on Eddington's vertex would be to shift it from A=94°, D=+12° to A=87°, D=+19°.

7. Correction to the Precession Constant

As the effect of the solar motion on the proper motions in α is of the form $-X \sin \alpha + Y \cos \alpha$, the sum of all the μ_α's does not change when we apply a correction for solar motion to them. If $\Sigma\ \mu_\alpha$ is not equal to zero, we can attribute this to an error in the precession constant. If dp is the resulting correction, then it will be seen that we can write

$$\Sigma\ (\mu_\alpha)_{10} = \frac{1}{10}\ \Sigma\ \mu'_\alpha \cdot \rho + \frac{1}{10}\ \Sigma\ \rho \cdot dp$$

where μ_α is the observed and μ'_α the true proper motion in right ascension and ρ the distance of each star. We may assume $\Sigma\ \mu'_\alpha\ \rho = \Sigma\ T = 0$, therefore

$$dp = \frac{\overline{10\ (\mu_\alpha)_{10}}}{\overline{\rho}}$$

Substituting the values found from our material we have

$$dp = \frac{10}{23}\ (+0^{s}.0041 \pm 0^{s}.0020), \text{ or}$$

$$dp = +0^{s}.0018 \pm 0.0009$$

This value, however, may still have to be increased to represent the true dp, as many of the proper motions used in this discussion were derived photographically and are practically independent of the precession constant.

It is hardly conceivable that an error so large as this one really exists in the precession constant. In the introduction to the *Preliminary General Catalogue*, Boss finds that the mean of his proper motions $\mu_\alpha \cos \delta$ is $-0''.0037$ (after symmetrical exclusion of the larger values). He then derives a correction to Newcomb's lumi-solar precession constant of

$$+0^{s}.00021 + \text{sine term}$$

Kobold[40] finds from an analysis of proper motions after Bessel's method a probable correction of

$$dp = -0''.0013.$$

Courvoisier[41] has investigated the proper motion of the members of the *Ursa Major* stream. He supposes that the deviations of their apparent motions from the result of a constant rectilinear velocity can be explained by assuming both that the stars are moving in orbits, curved around the center of Easton's galactic spiral and that the precession constant is in error. He thus finds corrections:

$$dm = +0''.0020 \pm 0''.0010 \quad dn = +0''.0017 \pm 0''.0014.$$

It will be seen from these values found by different observers, that even the sign of the correction to the precession constant is still doubtful, and the correction found in the present paper must therefore be attributed to other causes than an error in the precession constant.

8. Distribution of Velocities

In Fig. 6 all stars are represented by rectangular coördinates, x=galactic longitude, y=galactic latitude. To each star is attached an arrow indicating the direction of its motion, and the length of the arrow is proportional to the reduced proper motion. The stars are represented by dots whose diameters vary according to the absolute magnitude. For this absolute magnitude the value derived by the method outlined in section 3 was taken. A few reference circles of the equatorial system of coördinates and of a system with the solar apices as poles are shown. For the coördinates of the latter, of the apices of the two drifts, and of the true vertices the values adopted are:

		R. A.	Dec.	
Solar Apex		270°.0	+30°.0	
Apex Drift I		90.8	−14.6	Eddington
Apex Drift II		287.8	−64.1	
Vertices		94.2	+11.9	
		274.2	−11.9	

Stars with Greek letters or numbers have their names attached to them; the catalogue names of the very rapidly-moving stars are also given. A double or multiple star is indicated by a short line alongside the dot representing the star.

The existence of the solar motion is evident from a glance at this figure, and the apices of the two drifts are also indicated by the motions of the stars.

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[40] *Astr. Nach.*, **150**, 296, 1899.

[41] *Astr. Nach.*, **202**, 134, 1916.

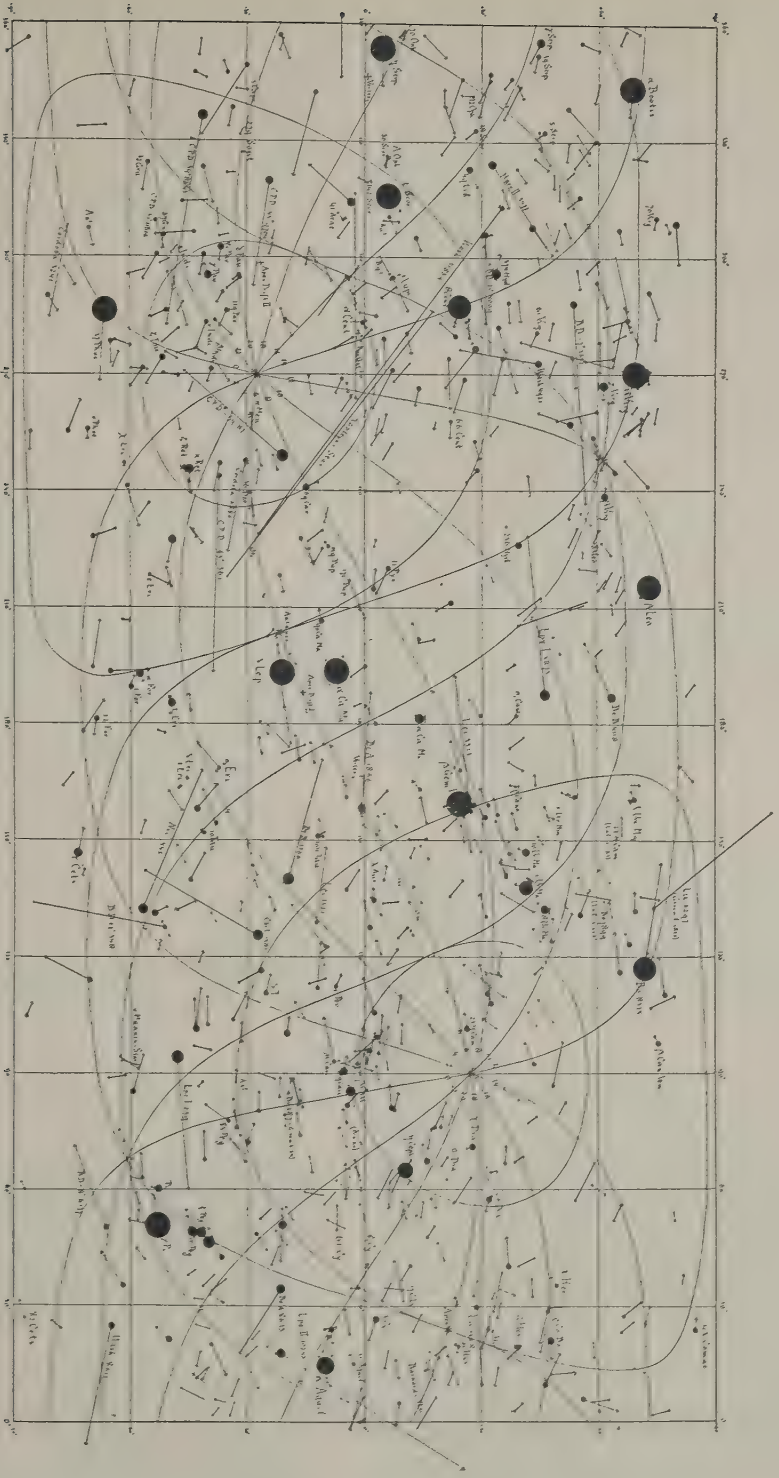

Fig. 6

Distribution of Tangential Velocities

One of the most striking features of this map is, however, the marked preference of motion parallel to the galactic plane, which is specially pronounced in the very rapidly moving stars, such as Lpz I 259, Be A 1366, −65° 361, Be A 1866, Lei 3313, Lpz I 3873, −7° 3632 and −34° 8843. This has been pointed out before by Adams and Joy[42] who analysed the space velocities of 37 stars with radial velocities exceeding 80 km./sec. That in our figure the star Be A 1366, which was found by them to be the most rapidly-moving star known, is not so conspicuous, is due to the method used for reducing the proper motions to the distance of 10 parsec. As was explained before, this increases the velocities of those stars, that are faint for their spectral class, like Lund 5297, Kapteyn's star, and Washington 5583-4. The motions of the two latter stars appear to be in opposite directions, but this is due to the particular kind of projection used, and does not show up in the space velocities.

Although the motions shown on the map are not the true tangential velocities as seen at a distance of 10 parsecs, it is interesting to observe their distribution. The frequency function, as derived empirically is given in Fig. 7. We note the rapid increase toward a maximum at 1″.25 (59.2 km./sec.) and the sharp drop immediately following it, and further the very slow decrease of the frequency with increasing velocity. (The highest velocity is that of the system Washington 5583-4, 26″.60 or 1260 km./sec.) It is at once clear that the distribution is not Maxwellian. We may try, however, to represent the logarithm of the frequency as a quadratic function of the logarithm of the velocity, thus:

$$\log \Phi\ (T) = a + b \log T + c\ (\log T)^2, \text{ or}$$

$$\log \Phi\ (T) = a' + c \left(\log \frac{T}{T_0}\right)^2$$

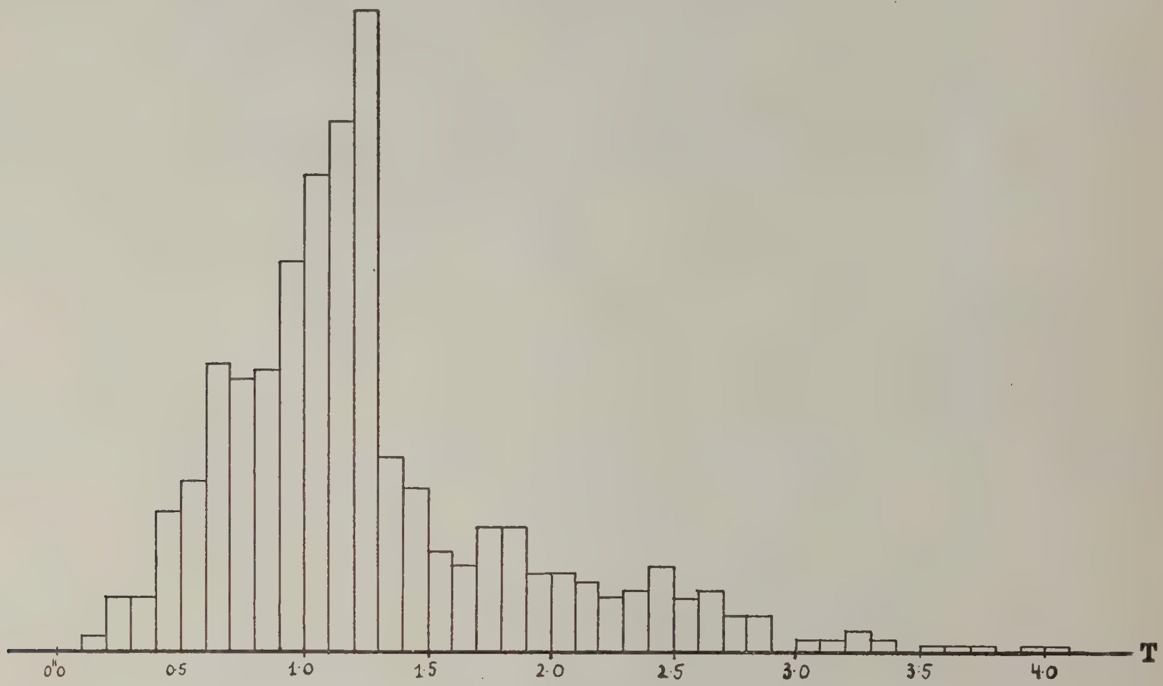

Fig. 7

Frequency Curve of Uncorrected Tangentical Velocities

For this purpose, the total number of velocities between 0″.1−0″.2, 0″.2−0″.4, 0″.4−0″.8............25″.6−57″.2, respectively, was taken as the frequency for the velocity 0″.14, 0″.28, etc. A least-squares solution then yields

$$\log \Phi(T) = 2.116 - 1.376 \left(\log \frac{T}{T_0}\right)^2,\ T_0 = 1''.74 = 82 \text{ km./sec.}$$

In Fig. 8 the agreement is shown between this formula and the observations. On account of the excess of large velocities, and the entire lack of velocities $<0''.1$ (due to the selection of only high-speed stars) the maximum of the parabola corresponds to a much higher speed than the true maximum of the frequency curve. The agreement is therefore poor.

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[42] *Proc. Nat. Acad. Sci.*, **5**, 239, 1919.

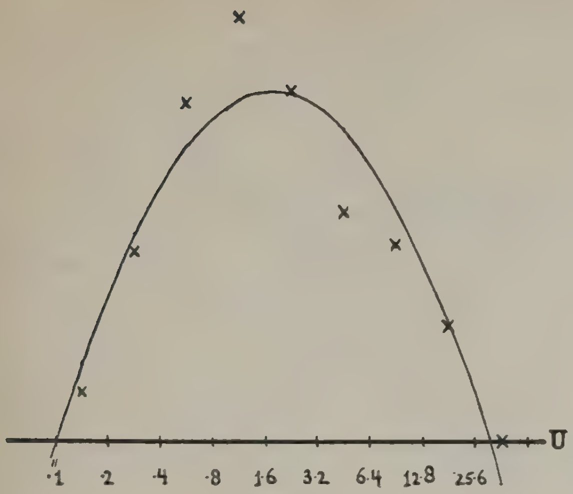

Fig. 8

Frequency Curve of Logarithms of Uncorrected Tangential Velocities

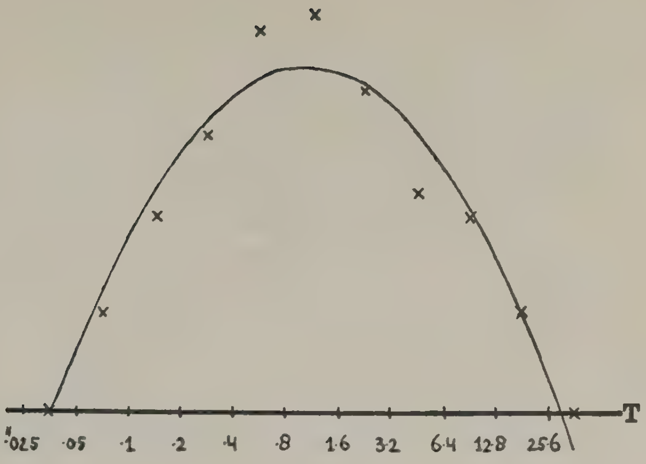

Fig. 9

Frequency Curve of Logarithms of Corrected Tangential Velocities

After correcting for the effect of the solar motion (solution C) we can again derive the frequency function of the tangential "motus peculiares." As we now have at least a few velocities below 0″.1, the influence of the large velocities is not so great as before, and the curvature of the parabola will be less (smaller c). Fig. 9 represents the agreement between the observations and the formula:

$$\log \Phi (U) = +2.090 - 0.976 \left(\log \frac{U}{U_0}\right)^2, \; U_0 = 49.5 \text{ km./sec.}$$

which written in another form, is:

$$\Phi (U) = A \frac{h}{\sqrt{\pi}} e^{-h^2 \log \left(\frac{U}{U_0}\right)^2}$$

$A = 145$, $U_0 = 49.5$ km./sec., $h = 1.50$ and accordingly $\epsilon = 0.472$.

The meaning of this formula is that we can regard the distribution of the logarithms of the tangential "motus peculiares" of these stars, as following an error curve with log 49.5 as mean value and 0.472 as mean error of log U (corresponding to 53.9 km./sec.).

Adams, Strömberg and Joy[43] have developed the frequency functions for the space velocities in the form

$$F (v)\, dv = \frac{h \cdot \text{mod}}{\sqrt{\pi} \cdot v} e^{-h^2 (\log v - A)^2} dv$$

It is easily seen, by taking the logarithms, that their function and mine are intrinsically the same. For the geometrical mean of their uncorrected space velocities (for K dwarfs) they find 54.1 km., which, as could be expected, falls considerably below the value that can be derived from my data.

9. Summary

1. A catalogue of 749 stars with proper motions exceeding 0″.50 annually has been compiled.

2. From statistical considerations, based for the larger part on the results of Kapteyn and Van Rhijn, the total number of stars with proper motions exceeding this limit is estimated to lie between three and four thousand.

3. The relation between the quantities $H = m + 5 + 5 \log \mu$ and $M = m + 5 + 5 \log \pi$ confirm the generally accepted theory of stellar evolution. However, the existence of a comparatively large number of absolutely faint white stars is made plausible. It is estimated that the absolutely bright yellow stars are not less than 0.25 per cent and not more than 1 per cent of all stars in space.

4. The relation between H and M is found to be practically linear for values of H larger than $6^m.5$. The correlation constant between H and M is computed as 0.858.

5. With the now-known linear relation between H and M as a base, the frequency curve of H makes it probable that the distribution in space of the absolute

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[43] *Contributions Mt. Wilson Obs.*, No. 210.

magnitudes of these stars follows closely an error curve with $7^{\mathrm{m}}.64$ as mean value and $2^{\mathrm{m}}.98$ as mean error. Extrapolating, we conclude that the corresponding error curve for all stars probably has a lower absolute magnitude as mean value.

6. The solar motion is computed to have the elements.

A = 289°.3, D = +40°.6, V = 29.3 km./sec.

7. The vertices of star streaming are found to be at:

A	D
104°.6	+12°.0
284°.6	−12°.0

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PARALLAXES OF STARS DETERMINED FROM SPECTRAL CLASS AND PROPER MOTION

In continuation of the lists published in *Lick Observatory Bulletin* No. **339** we give here two more lists of parallaxes determined from spectral class and proper motion. As the procedure is exactly the same as that followed previously it need not be described here.

THIRD LIST: THE PARALLAXES OF 64 STARS WITH LARGE PROPER MOTION

The present list contains only stars with proper motions exceeding $0''.50$ annually (see *Lick Obs. Bull.*, **11**, 1, 1923) for which parallaxes have not previously been published. The agreement between the spectral-class and proper-motion parallaxes is not so good as for the first list, and the differences have more of a systematic character, the proper-motion parallaxes generally being the larger. This systematic difference seems to vary both with apparent magnitude and with spectral class. Thus, from F to K the mean difference M_H-M_S decreases from $+2^{m}.4$ to $+0^{m}.1$ and from apparent magnitude $7^{m}.0$ to $10^{m}.0$ it increases from $+0^{m}.6$ to $+1^{m}.5$.

Among the several possible explanations are the following:

(*a*) Systematic errors are possible in the spectral classification of faint F and G stars.

(*b*) Systematic errors may exist in the reduction curve from H to M.

(*c*) It is possible that absolutely faint F and G stars do exist, thus introducing systematic errors into the mean M.

Attention may be called to the three white stars CPD−48°1280, −47°7499, and −40°7356, for all of which a fairly large parallax is expected from the proper motion.

The results are collected in Table I, the first six columns of which need no further explanation. The seventh column contains the quantity $m+5+5\log\mu$ for which the symbol H is used. Next are the parallaxes derived from spectral class and from proper motion, while the last column contains the adopted parallax. For this adpoted parallax the geometrical mean has again been taken after assigning double weight to the spectral class parallax.

TABLE I

Star	m	Sp	δ 1900.0	δ	μ	H	π_S	π_H	π
C P D −68° 3597	$8^{m}.7$	K0	0^{h} $0^{m}.3$	−68° 22′	$0''.53$	$12^{m}.3$	$0''.033$	$0''.038$	$0''.035$
C P D −38° 14	9.1	K5	11.1	−38 7	1.00	14.1	55	72	60
Cord B 118	7.8	G5	19.3	−27 35	0.67	11.9	30	40	33
Cord A 389	7.2	G5	44.5	−23 46	0.52	10.8	40	40	40
Cord B 315	7.2	G5	48.1	−30 54	0.63	11.2	40	44	41
Chri 174	9.4	K	50.4	+68 30	0.76	13.8	36	34	35
Lpz I 259	9.0	F2	54.5	+14 4	0.55	12.7	6	22	9
Gou 992	7.8	G0	1 0.1	−40 1	0.59	11.6	22	32	25
Cord A 869	8.9	K5	48.0	−22 56	0.86	13.6	60	53	58
Gou 1990	7.3	G0	56.3	−41 12	0.58	11.1	28	35	30

TABLE I—Continued

Star	m	Sp	δ 1900.0	δ	μ	H	π_s	π_H	π
Gou 2201	6.3	G5	2^h $6^m.4$	−51° 19′	2″23	$13^m.0$	0″050	0″100	0″063
Cord B 1044	8.1	G0	36.3	−30 34	0.60	12.0	19	32	23
Gou 4141	7.0	F8	3 40.2	−50 58	0.52	10.6	28	35	30
Gou 4297	8.4	K0	47.2	−42 53	0.62	12.4	36	41	38
Gou 5173	7.8	G0	4 30.1	−68 6	0.50	11.3	22	30	24
C P D −65° 361	9.6	G0	37.6	−65 39	1.47	15.0	10	33	15
Nic 1360	8.4	G5	5 26.6	+ 0 2	0.51	11.9	23	30	25
Alb 1860	8.8	K0	37.5	+ 2 39	0.54	12.5	30	34	31
Gou 6886	8.3	G0	45.7	−70 13	1.26	13.8	17	48	24
Gou 7009	6.5	K0	51.7	−50 23	0.60	10.4	87	69	82
C P D −69° 757	8.3	F0	7 38.4	−69 50	0.61	12.2	6	24	10
C P D −48° 1280	9.2	A3	43.8	−48 39	0.50	12.7		32	32
Cord B 4791	6.9	G0	8 2.9	−29 6	0.55	10.6	33	36	34
Gou 15615	7.4	K5	11 20.3	−61 6	0.51	11.0	120	100	113
C P D −43 5524	7.4	K5	36.2	−43 52	0.72	11.7	120	109	116
Be C 1671	8.2	G5	12 17.9	+73 48	0.51	11.7	25	33	27
C P D −77° 859	9.0	K5	33.6	−77 18	0.83	13.6	58	58	58
La Plata I 3869	8.3	G0	46.6	−56 1	0.60	12.2	17	30	21
Nic 3508	9.5	K2	55.2	− 2 10	0.73	13.8	26	34	29
C P D −40° 6050	9.2	G5	13 3.0	−41 6	0.69	13.4	16	33	20
B D +4° 2696	9.5	G	3.2	+ 4 19	0.54	13.2	12	25	15
C P D −34 5560	7.6	F5	7.0	−34 13	0.51	11.1	15	29	19
B D −7° 3632	9.6	F8	25.1	− 8 3	1.19	15.0	8	36	13
Cord B 8592	9.6	G0	27.8	−27 10	0.52	13.2	10	23	13
Gou 18442	7.4	G5	27.9	−59 0	0.51	10.9	36	38	36
Gou 18463	7.1	G0	28.7	−38 23	0.50	10.6	30	33	31
La Plata I 4383	7.7	G0	45.1	−56 56	0.61	11.6	23	33	26
Gou 18837	7.5	G5	46.3	−50 26	0.65	11.6	35	44	38
C P D −63° 3218	9.0	K0	14 13.0	−64 0	0.51	12.5	26	32	28
B D −7° 3856	9.3	K5	25.6	− 8 12	1.26	14.8	50	50	50
Lu 6145	8.2	G5	26.7	+35 53	0.51	11.7	25	32	27
C P D −47° 7499	9.5	B9	15 50.2	−47 21	0.85	14.1		52	52
C P D −40° 7356	10.1	A0	16 25.5	−40 6	1.05	15.2		66	66
Gou 23312	7.0	G0	17 9.2	−75 14	0.98	12.0	32	55	38
Gou 23548	7.6	F5	17.8	−41 24	0.59	11.5	15	33	20
Lu 7228	8.6	G0	36.2	+37 16	0.94	13.5	15	38	20
Alb 5924	9.0	K0	42.8	+ 4 59	0.70	13.2	28	36	30
C P D −56° 9037	8.7	K5	18 49.2	−56 6	0.50	12.2	66	52	61
B D −20° 5385	9.4	G0	58.0	−20 35	0.70	13.7	10	29	14
B D −0° 3676	9.3	G0	19 8.2	− 0 45	0.53	12.9	11	24	14
C P D −45° 9704	9.1	F8	16.5	−45 15	0.81	13.6	10	30	14
Alb 6750	10.5	K5	29.6	+ 4 21	0.58	14.3	29	31	30
Harv II 7019	9.1	K5	51.8	−12 49	0.51	12.6	55	44	51
Harv II 7042	7.6	G0	55.5	−12 31	0.50	11.1	24	30	26
δ Pavonis	3.6	G5	58.9	−66 26	1.63	9.7	209	166	193
Lpz II 10245	9.0	F2	20 33.7	+ 5 18	0.90	13.8	6	29	10
Gou 28703	6.6	G0	51.0	−44 29	1.14	11.9	38	63	45
C P D −34° 8843	8.7	F5	55.9	−34 27	1.31	14.3	9	42	15
Gou 29168	6.7	G0	21 10.8	−61 46	0.62	10.7	36	42	38
Gou 29865	7.3	G0	45.6	−73 54	0.52	10.9	28	35	30
C P D −51° 11806	9.1	G5	22 16.3	−51 17	1.58	15.1	17	50	24
La Plata I 7174	7.8	G0	29.8	−55 7	0.51	11.3	22	30	24
C P D −67° 3959	9.2	K0	23 11.0	−67 28	0.50	12.7	25	30	27
B D −8° 6177	9.7	G0	38.3	− 8 27	0.64	13.7	9	25	13

FOURTH LIST: THE PARALLAXES OF 185 CLASS A STARS

The material for this list consists of all Class A stars (B8 to A5) for which radial velocities have been given in *Publ. Domin. Astroph. Obs.*, **2**, 1, 1922. A trigonometric parallax is known in only 5 cases.

For the derivation of the spectral parallax the data given in *Publ. A. S. P.* **34**, 147, 1922, were used, except that for silicon stars and stars with moderately strong metallic lines the value $M=0^{m}0$, and for *c*-stars $M=-1^{m}4$ was adpoted. If the spectral class given by Plaskett differs from the Henry Draper estimate an absolute magnitude corresponding to the mean has been adopted; e.g. Boss 192, AO and F2, mean

$$M=\frac{1^{m}2+2^{m}9}{2}=2^{m}1.$$

For the proper-motion parallax the regression curve given in *Publ. A. S. P.*, **34**, 156, 1922, was used.

The results are collected in Table II which is arranged in exactly the same way as Table I except for the last column where the geometrical mean is now taken after assigning *equal* weights to the spectral- and proper-motion parallax.

TABLE II

Star	m	Sp	α 1900.0	δ	μ	H	π_s	π_H	π
23 Andromedae	$5^{m}73$	A5	0^{h} $8^{m}3$	+40° 29′	$0''195$	$7^{m}2$	$0''020$	$0''014$	$0''017$
Boss 87	5.92	B9	24.8	+59 25	047	4.3	11	12	12
λ Cassiopeiae	4.88	B8	26.2	+53 59	048	3.3	16	13	14
Boss 119	5.76	A3	30.8	+59 47	016	1.8	4	4	4
Boss 140	5.98	A5	36.3	+24 5	108	6.2	19	26	22
Boss 180	6.12	A0	44.7	+44 27	070	5.3	10	17	14
Boss 192	6.22	A0	48.0	+52 9	091	6.0	15	23	10
Boss 208	6.00	B9	52.2	+65 49	046	4.3	11	11	11
ψ^1 Piscium pr.	5.55	A2	1 0.3	+20 56	055	4.2	15	14	15
ψ^1 Piscium seq.	5.82	A0	0.3	+20 56	046	4.1	12	12	12
43 Andromedae	5.16	A2	1.2	+43 24	177	6.4	18	26	22
ψ^2 Piscium	5.63	A2	2.6	+20 12	125	6.1	15	22	18
35 Cassiopeiae	6.32	A0	14.4	+64 8	061	5.2	10	15	12
47 Andromedae	5.53	A0	17.9	+37 12	075	4.9	14	19	16
ω Cassiopeiae	5.54	A0	34.9	+67 32	056	4.2	8	14	11
Boss 440	5.18	A0	52.2	+64 8	049	3.6	16	13	14
Boss 447	6.14	A2	54.1	+11 49	035	3.8	12	9	10
63 Andromedae	5.56	A0	2 14.4	+49 42	050	4.1	8	13	10
Boss 533	6.54	A2	14.9	+56 47	011	1.7	5	3	4
Boss 573	6.51	A2	26.5	+51 52	010	1.5	10	3	5
μ Arietis	5.72	A0	36.7	+19 35	056	4.4	12	14	13
Boss 636	5.87	A0	43.0	+24 47	069	5.1	12	17	14
41 Arietis	3.68	B8	44.1	+26 51	132	4.3	28	33	30
π Persei	4.62	A2	52.4	+39 16	063	3.6	24	18	21
Boss 687	5.95	A2	56.2	+81 5	046	4.2	13	11	12
Boss 774	5.64	A0	3 18.2	+33 11	044	3.8	13	11	12
Boss 781	4.42	B9	21.0	+59 36	004	−2.6	7	1	3
Boss 799	6.41	A0	24.2	+73 0	035	4.1	9	9	9
7 Tauri	5.92	A2	28.5	+24 7	032	3.5	7	8	8
Boss 850	5.40	A0	38.8	+70 34	070	4.6	16	17	16
Boss 853	5.64	B9	39.0	+45 22	036	3.4	8	10	9
Boss 883	5.38	A3	44.3	+25 17	115	5.7	18	28	22
31 Tauri	5.62	B9	46.6	+ 6 15	007	−0.2	10	2	5
Boss 925	5.68	B8	56.4	+ 9 43	006	−0.4	12	2	5
Boss 969	5.64	B8	4 8.1	+61 36	026	2.7	11	7	9
Boss 1040	5.74	A5	22.1	+21 24	118	6.1	20	30	24
81 Tauri	5.49	A5	24.9	+15 29	110	5.7	22	27	24
Boss 1068	5.70	B9	28.4	+28 46	023	2.5	12	6	8
Boss 1114	5.35	A3	38.9	+10 58	098	5.4	19	25	21
5 Camelopard.	5.58	A0	46.9	+55 6	007	−0.2	8	2	4
18 Orionis	5.50	A0	5 10.5	+11 14	013	1.1	4	4	4
Boss 1260	5.39	A0	12.4	+33 39	046	3.7	8	12	10
Boss 1369	5.70	B8	30.9	+26 52	033	3.3	17	9	12
26 Aurigae	5.49	A2	32.2	+30 26	016	1.5	25	8	14
Boss 1383	5.70	B8	32.6	+ 7 29	026	2.8	11	7	9

TABLE II—Continued

Star	m	Sp	δ 1900.0	δ	μ	H	π_S	π_H	π
28 Camelopard.	6ᵐ79	A0	5ʰ 38ᵐ4	+56° 53′	0″045	5ᵐ1	0″09	0″011	0″011
137 Tauri	5.57	B9	46.7	+14 9	017	1.8	8	5	6
54 Orionis	6.56	B9	47.4	+20 17			8		8
35 Camelopard.	6.30	A5	56.6	+51 35	046	4.6	15	12	13
68 Orionis	5.70	B9	6 6.0	+19 49	015	1.6	12	4	7
Boss 1647	5.08	A2	26.2	+11 36	043	3.3	19	12	15
49 Aurigae	5.05	A0	29.0	+28 6	024	2.0	17	6	10
53 Aurigae	5.54	A0	32.1	+29 4	030	2.9	8	8	8
ψ Aurigae	4.80	A2	50.4	+45 14	025	1.8	22	7	12
Boss 1852	6.20	B9	7 6.4	+81 26	029	3.5	6	8	7
49 Geminorum	6.89	A0	6.7	+25 55	018	3.2	7	5	6
Boss 1859	6.66	B9	8.4	+24 53	016	2.7	2	4	4
Boss 1879	4.80	A2	10.9	+49 38	009	−0.4	22	3	8
η Canis Minoris	5.34	A5	22.6	+ 7 9	045	3.6	9	12	10
7 Canis Minoris	5.26	A5	26.9	+ 2 8	013	0.9	24	4	10
24 Lyncis	4.96	A2	34.5	+58 57	068	4.2	20	17	18
Boss 2027	6.84	A5	37.9	+24 29	042	4.9	12	11	11
ξ Canis Minoris	5.11	B8	46.5	+ 2 1	025	2.1	10	7	8
Boss 2206	5.87	A0	8 14.6	+24 20	034	3.6	12	9	10
Boss 2210	5.58	A2	16.2	+53 22	113	5.9	17	29	21
24 Cancri	7.10	A3	20.7	+24 52	095	7.0	8	22	13
29 Cancri	5.90	A2	23.0	+14 33	022	2.6	14	6	9
33 Lyncis	5.83	A2	28.3	+36 46	057	4.6	15	14	14
37 Cancri	6.48	A0	32.7	+ 9 56	042	4.6	9	11	10
40 Cancri	6.52	A0	34.4	+20 19	036	4.3	5	9	7
41 Cancri	6.32	A2	34.7	+19 54	036	4.1	11	10	10
42 Cancri	6.72	A5	35.0	+20 4	021	3.3	13	6	9
59 Cancri	5.48	A3	50.8	+33 18	098	5.5	17	25	20
63 Cancri	5.64	A5	52.0	+15 58	064	4.6	21	16	18
Boss 2494 pr.	6.4	A5	9 12.3	+35 47	058	5.2	14	15	14
Boss 2494 seq.	6.6	A5	12.3	+35 47	058	5.4	13	15	14
7 Leonis	6.21	A0	30.5	+14 49	042	4.3	10	11	10
22g Leonis	5.33	A2	46.3	+24 52	194	6.8	24	38	30
23 Leo. Min.	5.35	A0	10 10.6	+29 48	074	4.7	15	19	17
42 Leonis	6.10	B9	16.5	+15 29	049	4.6	10	13	11
53 Leonis	5.27	A0	44.0	+11 4	033	2.9	15	9	12
69 Leonis	5.40	A0	11 8.7	+ 0 29	040	3.4	14	10	12
Boss 2993	5.98	A0	16.9	+64 53	036	3.8	11	10	10
Boss 3027	6.13	A0	24.8	+81 41	146	6.9	11	35	20
Boss 3072	6.10	A0	35.0	+58 31	020	2.6	10	5	7
7 Virginis	5.24	A0	54.8	+ 4 13	024	2.1	7	7	7
3 Comae	6.34	A0	12 5.5	+17 22	013	1.9	6	4	5
Boss 3198	5.68	A0	12.5	+29 30	055	4.4	13	14	13
5 Draconis	5.41	A2	14.4	+75 43	026	2.5	17	7	11
Boss 3354	5.81	A0	48.3	+83 58	028	3.0	12	7	9
32 Camelopard.	5.28	A2	48.4	+83 57	032	2.8	18	8	12
14 Can. Venat.	5.11	B9	13 1.1	+36 20	027	2.3	16	12	14
Boss 3459	5.68	A0	16.7	+ 2 37	086	5.4	13	22	17
Boss 3494	5.41	A0	24.8	+60 28	091	5.2	14	23	18
81 Urs. Maj.	5.48	A0	30.3	+55 52	020	2.0	8	5	6
84 Urs. Maj.	5.53	A0	42.9	+54 56	015	1.4	4	4	4
Boss 3591	5.84	A5	48.7	+29 8	119	6.2	19	30	24
86 Urs. Maj.	5.65	A0	50.1	+54 13	026	2.7	13	7	10
3 Ursae Min.	6.34	A3	14 6.2	+75 4	056	5.0	12	14	13
κ Bootis	6.75	A5	9.9	+52 16	065	5.8	12	16	14

TABLE II—Continued

Star	m	Sp	δ 1900.0	δ	μ	H	π_S	π_H	π
Boss 3674	$6^{m}09$	A0	14^{h} $13^{m}8$	+51° 46′	0″025	$3^{m}1$	0″006	0″007	0″006
Boss 3730	6.57	A0	30.4	+47 13	038	4.5	10	10	10
108 Virginis	5.54	B9	40.4	+ 1 9	042	3.6	13	11	12
47 Bootis	5.59	A0	15 2.2	+48 32	064	4.6	8	16	11
Boss 3911	5.52	A3	17.2	+52 17	017	1.7	17	5	9
Boss 3984	6.75	A2	34.9	+43 56	004	−0.2	9	1	3
Boss 4004	5.48	A0	40.2	+52 40	062	4.5	8	16	11
υ Serpentis	5.72	A0	42.7	+14 25	061	4.6	13	15	14
45 Serpentis	5.63	A5	16 2.9	+10 10	029	2.9	21	8	13
8 Herculis	6.07	A0	4.2	+17 30	047	4.5	10	12	11
Boss 4113	5.40	A0	6.0	+68 4	068	4.6	14	17	15
19 Ursae Minoris	5.51	B8	13.7	+76 8	009	0.3	12	3	6
Boss 4160	5.98	A0	16.2	+73 38	025	3.0	6	7	6
23 Herculis	6.20	A2	19.1	+32 34	022	2.9	11	6	8
25 Herculis	5.53	A3	21.9	+37 37	026	2.6	17	7	11
Boss 4187	5.66	A2	22.2	+55 26	023	2.5	7	6	6
34 Herculis	6.22	A2	27.4	+49 10	084	5.8	12	21	16
Boss 4214	5.55	A0	28.8	+45 50	028	2.8	13	7	10
σ Herculis	4.25	A0	30.9	+42 39	037	2.1	25	10	16
Boss 4223	5.54	A3	31.3	+79 11	154	6.4	17	36	25
Boss 4263	6.18	A2	40.9	+55 53	091	6.0	6	22	12
Boss 4276	5.95	A0	45.0	+13 26	038	3.8	11	10	10
Boss 4349	6.36	A0	17 2.0	+43 57	017	2.6	5	5	5
Boss 4358	5.38	A5	4.5	+36 4	030	2.8	8	8	8
Boss 4359	6.27	A2	4.5	+40 39	040	4.3	6	10	8
63 Herculis	6.19	A3	6.9	+24 21	021	2.8	13	6	9
Boss 4382	5.47	A3	11.7	+62 59	047	3.9	17	13	15
Boss 4401	5.32	A2	16.1	+25 37	027	2.5	9	8	8
73 Herculis	5.70	A3	19.9	+23 3	063	4.7	16	16	16
Boss 4428	5.16	A5	23.7	+ 0 25	066	4.3	25	17	21
77 x Herculis	5.81	A2	24.1	+48 21	015	1.5	14	4	7
Boss 4432	5.66	A2	24.4	+60 7	035	3.4	15	9	12
78 Herculis	5.58	A0	27.9	+28 29	026	2.7	13	7	10
53 Ophiuchi	5.77	A2	29.8	+ 9 39	017	2.0	7	5	6
79 Herculis	5.67	A0	33.4	+24 22	023	2.5	13	6	9
Boss 4484	6.97	A2	38.1	+41 42	017	3.2	8	5	6
30 Draconis	5.19	A2	46.7	+50 48	208	6.8	18	50	30
Boss 4543	6.88	B9	54.9	+43 26	013	2.5	7	4	5
Boss 4572	6.06	A0	18 0.5	+48 28	024	3.0	6	6	6
Boss 4587	6.00	A3	3.8	+26 15	030	3.4	13	8	10
24 Ursae Min	5.86	A3	7.8	+87 0	054	4.6	14	15	14
107 Herculis	5.05	A5	17.1	+28 49	046	3.3	27	12	18
Boss 4661	5.04	A2	20.9	+55 26	023	1.8	20	6	11
Boss 4730	5.60	A0	36.7	+62 26	032	3.1	4	8	6
46 Draconis	5.08	A0	40.7	+55 26	023	1.9	10	6	8
9 Lyrae	5.16	A2	46.2	+32 26	025	2.2	18	7	11
10 Aquilae	5.94	A3	54.2	+13 46	052	4.5	7	13	10
19 Lyrae	5.77	A0	19 7.9	+31 7	014	1.5	7	4	5
21 Aquilae	5.10	B8	8.7	+ 2 7	007	−0.7	5	2	3
22 Aquilae	5.40	A2	11.6	+ 4 40	017	1.6	8	5	6
Boss 4905	5.46	A0	11.9	+14 23	018	1.8	14	5	8
Boss 4939	6.24	A0	17.4	+54 12	038	4.1	9	10	10
Boss 4957	6.31	B9	20.8	+50 5	010	1.3	3	3	3
5 Vulpeculae	5.58	A0	21.9	+19 54	040	3.6	13	11	12
Boss 5035	6.20	A3	38.5	+40 1	031	3.7	13	8	10
υ Aquilae	5.72	A2	40.8	+ 7 22	055	4.4	14	14	14
Boss 5057	5.90	A0	44.4	+69 6	028	3.1	12	7	9
14 Sagittae	5.47	A0	58.9	+15 45	012	0.9	4	3	3
21 Vulpeculae	5.20	A3	20 10.2	+28 24	026	2.3	20	7	12
40 Cygni	5.45	A0	23.9	+38 7	073	4.8	13	19	16

TABLE II—Concluded

Star	m	Sp	δ 1900.0	δ	μ	H	π_S	π_H	π
Boss 5259	$6^{m}99$	A0	20^{h} $26^{m}5$	+10° 57′	0″023	$3^{m}8$	0″007	0″006	0″006
Boss 5260	6.39	A0	26.7	+10 55	004	−0.6	8	1	3
Boss 5264	5.87	B9	27.0	+55 44	016	1.9	11	4	7
Boss 5283	5.59	B9	30.6	+46 21	029	2.9	8	8	8
73 Draconis	5.18	A2	32.8	+74 37	016	1.2	5	4	4
13 Delphini	5.59	A0	42.8	+ 5 38	006	−0.5	8	2	4
56 Cygni	5.07	A5	46.6	+43 41	178	6.4	26	44	33
Boss 5442	5.57	A0	21 4.4	+29 48	027	2.8	13	7	10
Boss 5447	5.73	B9	7.1	+53 9	022	2.4	12	6	8
35 Vulpeculae	5.38	A0	23.3	+27 11	041	3.4	8	11	9
74 Cygni	5.09	A5	32.9	+39 58	009	−0.1	26	3	9
79 Cygni	5.62	A0	39.3	+37 50	038	3.5	13	10	11
27 Aquarii	5.50	A0	42.2	+ 2 14	014	1.2	8	4	6
Boss 5621	5.68	B9	46.9	+19 22	037	3.5	7	10	8
Boss 5630	5.76	A0	48.9	+19 13	019	2.2	12	5	8
Boss 5656	6.49	A0	56.0	+57 10	016	2.5	9	4	6
21 Pegasi	5.75	A0	58.4	+10 54	016	1.8	7	4	5
Boss 5722	6.36	B9	22 8.3	+71 37	031	3.9	5	8	6
Boss 5737	5.70	A0	10.5	+42 28	058	4.5	13	14	13
Boss 5815	5.80	A3	28.0	+39 16	019	2.2	15	5	9
Boss 5826	6.26	A0	30.4	+69 51	062	5.3	10	16	13
Boss 6032	6.74	A2	23 22.0	+70 8	053	5.3	9	13	11
69 Pegasi	5.87	A0	22.7	+24 37	053	4.5	7	13	10
79 Pegasi	5.91	A3	44.6	+28 17	074	5.2	7	18	11
Boss 6161	6.71	A0	54.8	+86 9	038	4.6	8	10	9

NOTES TO TABLE II

Boss 119	Instead of the Boss proper motion of 0″001, a value of 0″016, derived from 20 meridian observations was adopted. $M_S = -1^{m}4$ as the spectrum resembles that of *α Cygni*.
Boss 636	Very faint silicon lines, therefore $M = +1^{m}2$ was adopted.
41 *Arietis*	Miss Maury has VIac.
Boss 1383	May be a binary, no correction applied.
68 *Orionis*	Miss Maury has VIIab.
81 *Urs. Maj.*	Miss Maury has VIII P.
κ Bootis	Double star.
σ Herculis	Miss Maury has VIIb.
30 *Draconis*	The weighted mean of the Yale (0″019) and Allegheny (−0″004) parallaxes is 0″003. A strange case, as the proper motion seems to be very well established, and, were the trigonometric parallax correct, would lead to a linear motion of 350 km/sec. The radial velocity is −59.1 whereas the computed velocity (61 *Cygni* cluster) is −57.9 km/sec. It is thus made probable that the spectral parallax which accords best with the cluster parallax is nearest to the truth.
9 *Lyrae*	Miss Maury has IX.
21 *Aquilae*	"K and 4481 of hair line sharpness;" M may be -4^{m}.

The agreement between the two series of parallaxes can, on the whole, be regarded as satisfactory, for even in the worst case (Boss 3984, $\pi_S = 0''009$ $\pi_H = 0''001$) the discordance is not larger than occurs between two first-class modern photographic determinations.

The systematic difference between the two series leaves nothing to be desired, the mean difference in absolute magnitude taken in the sense $M_S - M_H$ being only $+0^{m}22$, corresponding to only 11 per cent difference in the parallaxes.

In Table III a comparison is given with (a) the parallaxes determined by Adams by the spectrographic method; (b) the trigonometric values; and (c) parallaxes computed on the supposition that the stars belong to moving clusters.

TABLE III

Star	$\pi_{H,S}$	π_{AS}	π_{tr}	$\pi_{mv.cl.}$
λ Cassiopeiae	0″014			0″014 Perseus
35 Cassiopeiae	12			16 Perseus
63 Andromedae	10			12 Perseus
Boss 774	12			11 Perseus
7 Tauri	8		2	
Boss 853	9			9
Boss 1040	24	26		27 Hyades
81 Tauri	24	27		28 Hyades
Boss 1114	21	27		29 Hyades
5 Camelopardalis	4	12		
26 Aurigae	14	26		
40 Cancri	7	10		7 Praesepe
41 Cancri	10	17		7 Praesepe
42 Cancri	9	14		
Boss 2494	14	18		
7 Leonis	10	10		7 Praesepe
22 Leonis	30	24		

Star	$\pi_{H,S}$	π_{AS}	π_{tr}	$\pi_{mv.cl.}$
23 Leo. Min.	17	10		
3 Comae	5	8		
14 Canum Venat.	14	12		
η Bootis	14	16	28	
Boss 3911	9	16		
23 Herculis	8	8		
25 Herculis	11	13		
77 Herculis	7	12	18	
79 Herculis	9	10		
30 Draconis	30	16	3	13 61 Cygni
5 Vulpeculae	12	10		
40 Cygni	16	14		
56 Cygni	33		31	
79 Cygni	11	14		

It will be seen that the agreement with all three is entirely satisfactory as the differences are:

$$\pi_{\text{Adams}}-\pi_{\text{S,H}}=+0\overset{''}{.}0016 \quad \text{(24 stars)}$$

$$\pi_{\text{trig}}\quad-\pi_{\text{S,H}}=-0.002 \quad \text{(5 stars only)}$$

The mean parallax for the five stars belonging to the *Perseus* cluster is 0".0114 whereas the computed value is 0".0124, in excellent agreement. For the *Hyades* these values are 0".024 and 0".028 respectively and for *Praesepe* 0".009 and 0".007 (Kohlschütter). For the last two clusters Adams's parallaxes give 0".027 and 0".012, respectively.

KNUT LUNDMARK.
September 2, 1922. WILLEM LUYTEN.

ON THE RELATION OF MEAN PARALLAX TO PROPER MOTION AND APPARENT MAGNITUDE

THIRD PAPER

In two recent papers I have given new determinations of the formulae connecting mean parallax with proper motion and apparent magnitude. I have shown that the assumption:

$$m+5+5\log\pi=a+c\,(m+5+5\log\mu),\ \text{or}\ M=a+cH$$

is not at variance with the facts, when a and c are made dependent on spectral class. This conclusion is supported by a comparison with formulae derived by other investigators.[1] The most recent general formula was derived by Kapteyn and van Rhijn[2] and reads:

$$\log\pi_{m,\,\mu}=-0.690-0.0713m+0.645\log\mu$$

or:

$$M=-1.680-0.0015\,m+0.645\,H.$$

The coefficient of m is too small to have any real significance and can safely be neglected.

From an investigation of stars with proper motions exceeding 0".50 annually the writer found the relation:

$$M=H-5\overset{m}{.}58^{3}$$

Adams, Joy, Strömberg and Burwell[4] also find a marked correlation between the absolute magnitudes of the Cepheids and the quantities $0.2m+\log\mu$. It may appear that this might have been expected beforehand as the υ-components of the proper motions have been used for deriving the absolute magnitudes. However, this was only done to establish the *system*, whereas the *individual* absolute magnitudes were derived from spectral line intensities.

Now that our assumption:

$$M=a+c\,H$$

appears to be substantially correct, it may be of interest to examine its relation to the fundamental laws of stellar statistics.

Starting from assumed forms for the density-, the velicity-, and the luminosity-law, Schwarzschild[5] has, analytically, derived formulae for a large number of statistical parameters. His three fundamental assumptions are:

$$\text{Density:}\quad \mathrm{D(r)}=10^{a_0-a_1\rho-a_2\rho^2}\qquad \rho=-5.0\log r \quad (1)$$

$$\text{Luminosity:}\quad \Phi(\mathrm{J})=10^{b_0-b_1M-b_2M^2}\qquad M=-2.5\log J \quad (2)$$

$$\text{Velocity:}\quad \Psi(\mathrm{T})=10^{c_0-c_1G-c_2G^2}\qquad G=-5.0\log T \quad (3)$$

$$T=\text{tangential velocity}=\mu r.$$

He then finds:

$$\log\bar{\pi}_{m,\mu}=R_0-R_1m-R_2g \quad \text{..............} \quad (4)$$

where $g=+5.0\log\mu$ and the coefficients R_0, R_1, R_2 are related to the nine fundamental constants by the equations:

$$R_0=-0.1\,\frac{a_1+b_1+c_1+1.1}{a_2+b_2+c_2},$$

$$R_1=\frac{0.2\,b_2}{a_2+b_2+c_2},\quad R_2=\frac{0.2\,c_2}{a_2+b_2+c_2}.$$

Transforming our equation (4) to the form:

$$M=a+c\,H$$

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[1] v. Rhijn's dissertation, Groningen, 1915, formulae for A and B stars.

[2] *Mt. Wilson Contributions*, No. **188**.

[3] *Lick Obs. Bull.*, **11**, 1, 1923.

[4] *Mt. Wilson Contributions*, No. **199**, p. 18.

[5] *Astr. Nach.*, **190**, 361, 1912.

we obtain:

$$M(\bar{\pi})=(5+5R_0-25R_2)+(1-5R_1-5R_2)m$$
$$+5R_2H \ldots\ldots\ldots\ldots \quad (5)$$

This $M(\bar{\pi})$ and the one derived from Kapteyn and van Rhijn's formula are computed from the arithmetical mean of the parallaxes whereas I have used the mean M or the M derived from the geometrical mean of the parallaxes. In order to find the relation between these two we make the supposition that "if π be the true parallax of a star and π_0 the most probable mean parallax of stars of the same magnitude and proper motion, the quantities

$$z=\log\frac{\pi}{\pi_0}$$

are distributed in accordance with the law of errors."[6]

The difference between the two absolute magnitudes mentioned above is then given by:

$$\frac{5}{h\sqrt{3.1416}}+5\log\left(e^{-\frac{1}{4\,\mathrm{mod}^2h^2}}\right)$$[7]

where h is the measure of precision of the error curve $z=\log\frac{\pi}{\pi_0}$ and has to be derived empirically. We know $h=\frac{0.4769}{\rho}$ and for ρ we shall adopt the value 0.15.

Finally we have:

$$M\,(\overline{\log\pi})-M(\bar{\pi})=+0^{\mathrm{m}}\!.60.$$

This will affect only the constant a and leave the others unaltered. According to Kapteyn and van Rhijn's general, and my special formulae for different spectral classes, we must then have:

$$1-5\,(R_1+R_2)=0,$$
$$\text{or } a_2=0.$$

This would lead to the conclusion that the density law is of the simple form:

$$\mathrm{D}\,(r)=10^{a_0-a_1\rho}$$

instead of the form given by (1), or, in any case, that the coefficient of ρ^2 is very small compared with the coefficients of the quadratic terms in Φ and Ψ. The relation $M=H-5^{\mathrm{m}}\!.58$ found by me for stars with proper motion above a certain limit and therefore applicable to the stars in a limited volume of space round the Sun, leads to

$$1-5(R_1+R_2)=0$$
$$\text{and } 5R_2=1,$$
$$\text{or } a_2=0,\ b_2=0.$$

This would mean that the quadratic term disappears in the luminosity law as well as in the density law. For the density we cannot draw any further conclusions as it is well known that Schwarzschild's form leads to $\mathrm{D}=0$ for $r=0$ and is therefore not valid for small distances. In this particular case we can safely put

$$\mathrm{D}(r)=\mathrm{C}.$$

For the other formulae, however, stars were used occupying regions in space where the density is *not* constant, and we therefore come to the conclusion that at least one of our three fundamental laws is not expressible in a simple exponential form. It is generally accepted that the luminosity curve closely resembles an error curve and the simplest assumption we can make is therefore that $\Psi\,(T)$ is not of the form adopted by Schwarzschild.

This has been found before from empirical data and the simplest form in which we can at present express $\Psi\,(T)$ with any accuracy is as the sum of two error curves.

WILLEM J. LUYTEN.

July 1, 1922.

Issued February 6, 1923.

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[6] v. Rhijn's dissertation, p. 5.

[7] cf. *Publ. A.S.P.*, **34**, 158, 1922.

UNIVERSITY OF CALIFORNIA PUBLICATIONS

ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 346

OBSERVATIONS ON THE DEFLECTION OF LIGHT IN PASSING THROUGH THE SUN'S GRAVITATIONAL FIELD

MADE DURING THE TOTAL SOLAR ECLIPSE OF SEPT. 21, 1922

The observations forming the subject of this paper represent a part of the program of the Wm. H. Crocker Eclipse Expedition to Wallal, Western Australia, of which Mr. Campbell has given a detailed report in another publication.[1] That report also contains a full account of the previous efforts made to determine the light deflection by the Sun's gravitational field during total solar eclipses, and of the results obtained.

Since the British expeditions of 1919 published their measures[2] on this subject, several physicists and astronomers have pointed out various sources of error that might enter into this problem, which consists in comparing by accurate measures a photograph of the stars surrounding the eclipsed Sun with a photograph of the same stars taken at night several months before or after the eclipse, when the Sun is in another part of the sky and has no disturbing influence on the apparent positions of these stars. The most important of these sources of error are:

1. Distortion in the reproduction of the star field by the optical parts of the instruments. In view of the differential character of the measures such distortions are only to be feared in case they are different for the eclipse photographs and the night comparison plates. This is most likely to occur if the optical parts of the instrument contain mirrors. The experience of the British expedition to Sobral in 1919 has shown such mirrors to be easily deformed in consequence of the inevitable temperature changes during a total eclipse.

2. Disturbing effect of the uneven illumination of the background,[3] the intensity of which is gradually diminishing with increasing distances from the Sun. There may be a physiological effect in bisecting a star image seen on such a background, but there may also be a real shifting of the center of a star's image if this is photographed on a background of uneven intensity. In view of the gentle gradation, hardly noticeable in the field of the measuring microscope, this effect can be but small and may be negligible.

3. Systematic distortion of the photographic film during the process of drying.[4] According to Ross the blackened part of the plate corresponding to the corona should dry the more rapidly, and we should expect contraction of the film toward the inner corona. Such distortion is favored by the high temperatures encountered by expeditions to tropical countries; it should have the tendency to make the measured light deflections too small.

4. Abnormal refraction in the Earth's atmosphere accompanying the changes of temperature produced by the passing of the Moon's shadow.[5]

It has been stated, also, that other causes than the Sun's gravitational field may be responsible for all or a part of the observed light deflections. As such should be mentioned:

5. Refraction in an extended solar atmosphere.[6]

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[1] *Publ. A. S. P.*, 35, 11, 1923.

[2] F. W. Dyson, A. S. Eddington, C. Davidson: *A Determination of the Deflection of Light by the Sun's Gravitational Field, from Observations made at the Total Solar Eclipse of May 29, 1919.* *Mem. R. A. S.*, 62, *Appendix*, 1920.

[3] K. F. Bottlinger: *Die astronomischen Prüfungsmöglichkeiten der Relativitätstheorie. Jahrbuch für Radioaktivität und Elektronik*, 17, 149 and 152, 1920.

M. Wolf: *A. N.*, 212, 181, 1920.

[4] F. Ross: *Image Contraction and Distortion on Photographic Plates. Ap. J.*, 52, 98; Silberstein: *M. N.*, 80, 630, 1920.

[5] A. Anderson: *Nature*, 104, 354, 372, 393, 436, 468, 563, 1919–20.

[6] H. F. Newall: *M. N.*, 80, 22, 1919; *The Observatory*, 42, 428, 1919; 43, 145, 1920. W. Anderson: *A. N.*, 218, 251, 1923.

6. The phenomenon observed by Courvoisier,[7] called "yearly refraction." It consists of an apparent displacement of the stars away from the Sun, but this displacement extends to large angular distances from the Sun. No physical explanation of the yearly refraction has been given as yet, and its amount in the immediate neighborhood of the Sun is not known.

In order to secure high value for the present observations, an attempt was made to eliminate objections based on these points, as far as possible, by taking the following precautions:

To mount the cameras equatorially, thus eliminating the need of any mirrors.

To use wide-angle objectives, allowing us to photograph a relatively large area of sky. A large field is not only desirable in order to increase the number of stars on the plates, but it is most important for a good determination and elimination of the scale value of the plates. This scale value, *i.e.,* the angle on the celestial sphere corresponding to a certain length (unit of measure) on the plate, depends on the focal length of the telescope, and is subject to temperature influences difficult to control. Experimental determinations of this constant do not promise much success under the rapidly varying eclipse conditions. It therefore seemed best to follow the practice, generally accepted in the photographic determination of star positions, of obtaining the scale of the plate from the star images themselves. However, in our problem of comparing the eclipse photographs with the night plates, the effects of the difference of scale of the two plates are mixed up with those of the light deflection; both produce an apparent displacement of the star images radially with reference to the Sun. With increasing distances of the stars from the center of the plate the effect of the scale difference increases proportionately, whereas the light deflection decreases rapidly. It is thus possible to separate the two effects by a least squares solution, and the separation will be the more complete the larger the field of the plate.

An equally important reason for advocating a large field is that it increases the prospects of determining whether the amount of light deflection for any star is inversely proportional to the distance of the star from the Sun's center, as predicted by Einstein's theory. If the observations conform to this law, they will make a much stronger case in favor of the new theory, and some of the other possible causes of such light deflections can the more easily be rejected or isolated.

To guard the purely differential character of the measures, the night comparison photographs were taken as nearly as possible under the same conditions, and at the same hour-angle and zenith distance, as those of the eclipse photographs. Unfortunately the arrangements for the expedition did not make it possible to obtain the comparison plates at the eclipse station itself. The selection of Tahiti as the site for the comparison observations necessitated dismounting, transporting and reassembling the telescopes between the two sets of observations to be compared. As a check against any errors that might be introduced on this account, an auxiliary star group was selected with center at R.A. $18^{h}\,5^{m}.5$ and Decl. $+1^\circ\,1'$ (following the eclipse star field by $6^{h}\,14^{m}.9$, but at the same declination). This check field could be photographed at night, in the proper hour-angle, on the island of Tahiti in May, as well as at Wallal in September. At both epochs it was more than 90° distant from the Sun, and therefore unaffected by any light deflections. The expedient of making the exposures of this check field on the same plates and during the same night as the comparison photographs of the eclipse field, and of recording the same check field on the eclipse plates on the nights before and after the eclipse, gives not only a valuable check on the instrumental conditions at both observing stations, but also serves to eliminate any possible effects of errors mentioned in paragraphs 2 and 3, page 41.

It is desirable that the results be based on a number of stars near the Sun, and that these be distributed fairly well in all position-angles, so as to reduce the influence of the plate constants to a minimum. This condition could only be fulfilled by reaching stars slightly fainter than tenth magnitude. The star field of the 1922 eclipse is very poor in bright stars, only two stars brighter than ninth magnitude being situated within 1° from the Sun's center, whereas at the 1919 eclipse seven stars brighter than sixth magnitude were found in a similar field. Every effort therefore had to be made to photograph as faint stars as possible.

When photographing stars on an illuminated sky background there is a certain limit of exposure time which gives the best results; an increase of exposure beyond this limit will add very few or no fainter stars, because the blackening of the background of the plate will be intensified at the same rate as the star images; a moderate fogging, on the contrary, would help to bring out the faintest stars. Special experiments on this point were made in preparation for the eclipse by photographing star fields near the full Moon with the Crossley Reflector, with varying exposure times. It was concluded from these tests that a 2-minute exposure with the 15-foot camera (ratio of aperture 1:36) should not exceed the admissible amount of fogging of the plate. Similar experiments on the best method and duration of development will be referred to later. The procedure decided upon proved correct; the 2-minute exposures during the eclipse show as many faint stars as the 3-minute exposures at night in Tahiti. Stars down to the photographic magnitude 10.5 have measurable images. This is probably the first time that such faint stars have been photographed or observed during a solar eclipse.

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[7] *Beob. Ergebn. d. Sternw. Berlin,* **15**, 1913; *A. N.,* **211**, 305, 1920.

INSTRUMENTS

Of the two twin cameras, of 15 feet and 5 feet focal length, respectively, only the observations with the longer cameras form the subject of the present communication. The plates obtained with the other cameras, though quite successful, have not yet been measured. Pictures of the 15-foot cameras and of the observing house are found in Mr. Campbell's report.[8] The common tube of these cameras, of rectangular cross section, is a framework of channel, tee and angle steel, with two heavy end castings, one carrying the objectives and the other the plate holders. This frame, weighing about 700 lbs., is made light-tight by covering it with one thickness of black cloth and one thickness of rubberized cloth, the latter black inside and white outside. The two halves of the tube are separated optically by a number of steel diaphragms. The 5-inch doublet objectives[9] are mounted in brass tubes 28 inches long. Several bars on the outside of each objective tube are provided with parts of a screw thread so as to fit into a ring with a complete inside thread. By turning this ring the objective is moved in or out along its optical axis, for focussing; and once the focus is set, the objective tube is clamped. Objective caps, mounted on a wire frame and operated from the plate end of the telescope by means of a string, serve for starting and ending the exposures. This form of shutter, though very light, was not found quite satisfactory, as its operation inevitably led to perceptible vibrations of the telescope. It would be preferable to have a shutter unconnected with the telescope tube. The plateholders, of aluminum alloy, containing the 17 × 17 inch plate glass plates, ¼ inch thick, with Seed 30 emulsion, were held in place in the telescope by three clamping screws pressing against three adjusting screws. The latter screws served to set the plate perpendicular to the optical axis.

Following the design of the English equatorial mounting, the camera tubes pass centrally through the polar axis (8 feet long), consisting of a metal framework similar to the camera frames. For the sake of greater rigidity of the polar axis, only a few degrees of motion around the declination axis were allowed. A steel bar connecting the lower end of the polar axis and the plate end of the camera served to clamp the telescope in declination, once it was set. No declination slow motion nor any setting circle was provided. A clock driving arm, 10 feet long, could be clamped to the lower end of the polar axis. The end piece of this arm glided on rollers on a metal plate screwed to a board and inclined so as to be in the plane of the equator. A steel cable released by the drum of a clockwork held this clock arm, allowing it to glide down at the required speed by its own weight, carrying with it the polar axis and cameras properly balanced. The cable was not directly fastened to the driving arm, but to a metal piece, movable on hinges, with a finely-threaded screw which thus furnished a right ascension slow motion. By means of a slender cord the slow motion could be operated by the observer at the eye piece of the guiding telescope.

Piers of solid wood structure supported the roller bearings of the polar axis; their bases were bolted to seven small concrete blocks forming the foundation.

The guiding telescope consisted of a square wooden tube fastened to the cameras by three brackets and carrying a visual 4-inch objective of 15 feet focal length. *β Virginis,* of magn. 3.5, 1½° north-preceding the center of the eclipsed Sun, was a suitable guiding star, and the guiding telescope had to be set off from the axis of the cameras at the required angle. 70 *Ophiuchi* was selected as guiding star of the auxiliary star field, and the eye piece of the guiding telescope was provided with a declination micrometer to make it possible to set the cross wire on each of the two stars (differing in declination by 19′) without changing the declination setting of the cameras. The cross wire was made of very fine metal wire. Projecting it on the slightly extrafocal image of the guiding star it could be used even for the night observations without illumination.

MOUNTING AND ADJUSTMENT OF CAMERAS

For shipping, the instrument was taken to pieces so that no package exceeded 250 lbs. in weight. All parts were properly marked in order to make any interchange impossible. The installation of the instrument at Tahiti and again at Wallal proceeded according to a carefully worked out plan and did not encounter any difficulties.

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[8] *Publ. A. S. P.*, **35**, plate III, p. 18; plate II, p. 11; 1923.

[9] See R. Trumpler: *Comparative Tests of two Wide-Angle Photographic Objectives, Publ. A. S. P.*, **35**, 1923.

Among the necessary adjustments of the cameras, the following points should be mentioned:

The objectives demanded accurate centering. A metal plate with a small hole in its center was inserted in one of the plate holders. A polished glass plate outside of this hole, inclined at 45°, allowed us to throw a small bundle of light on the objectives, and to observe its reflections from the different surfaces of the lenses. Each objective was so centered that these reflections fell together.

To adjust the plane of the photographic plate perpendicular to the optical axis, a small telescope with a micrometer was screwed into the hole of the metal plate, used for centering. According to the method of Schlesinger[10] the micrometer wire is set on the edges of the objective diaphragm, the plate is turned 180° in position-angle, and the operation repeated. The micrometer readings in the two positions of the metal plate should show no difference. As perfect adjustment is impossible, the small residual error is finally measured for each plate holder and taken account of by calculation.

Setting and clamping the cameras in declination, and adjusting the guiding telescope so that the guiding star (*β Virginis* at Tahiti, 70 *Ophiuchi* at Wallal) was on the cross wire when its image in one of the cameras fell exactly on a certain mark on the ground glass, were rather trying operations. It was however desirable to have the coördinates of the plate center agree closely with those of the eclipsed Sun (R.A. $11^h\ 50^m.6$ and Decl. $+1°\ 1'$, 1922.0) at both observing stations.

The focus was determined at Tahiti and at Wallal by making a series of exposures of a star field on the same plate, changing the focal settings by 1.5 mm. between successive exposures. The images of a number of stars, evenly distributed over the plate, were then examined with the microscope, and for each one the best focal setting was estimated. An average value, about 1 mm. smaller than that of stars at the center of the plate, was adopted. On account of the small ratio of aperture the images thus obtained are sharp and round up to 3° from the plate center.

OBSERVATIONS AT TAHITI AND WALLAL

Mr. Trumpler, in charge of the comparison observations at Tahiti, arrived at this island on April 11, with the necessary equipment. A suitable location for the observations was found in Papeete near the western city limit, close to the beach. The instrument was set up in the garden of a private residence, and on the lower floor of the house a work room was kindly made available, where a temporary dark room was installed. Mr. P. C. Lieber rendered valuable services as assistant throughout the work at Tahiti.

The observations with the 15-foot cameras were made during the period from May 7 to May 20. The eclipse star-field was photographed at $9^h\ 40^m$ to $10^h\ 30^m$ in the evening, the plate holders were left unchanged in the telescope, closing only the slides, and at 4^h to $4^h\ 50^m$ in the morning the plates were exposed to the check field. The exposures at Tahiti were increased to 3 minutes (as compared with 2 minutes at Wallal) to take account of any difference in the transparency of the air, or of the effect of the fogging of the background during the eclipse in bringing out the fainter stars. Four pairs of plates were secured, three of which had the eclipse and check fields photographed on the same night.

The separate operations for an exposure were: inserting the plate holders, clamping them tightly, and setting the telescope on the guiding star. When the vibrations caused by pulling the slides had subsided, the guiding star was put exactly on the cross wire, and the exposure started by pulling the string of the objective shutter. No guiding was done in declination, and in right ascension not much operation of the slow motion was required during the 3-minute exposures, as the clockwork was well adjusted; but still the few corrections undoubtedly meant a considerable improvement of the star images. Closing the shutter and plateholder slides completed the operation.

The general observing conditions in Tahiti were rather variable, and, as the rainy season was not quite over, considerable cloudiness prevailed on many nights, which was especially a handicap because the exposures had to be made at a specified hour and minute. On a few of the nights the steadiness and definition of the star images were perfect, and some of the Tahiti star images are the best so far obtained with this instrument. On other nights, however, there was noticeable unsteadiness, causing diffused images. The transparency of the air was inferior to that at Mount Hamilton. No trouble was encountered from wind; the night temperatures were remarkably uniform (69° to 74° F); the relative humidity was high; and care had to be taken to prevent fogging of the lenses.

At Wallal Mr. J. B. O. Hosking of the Melbourne Observatory was most helpful during the construction period, and he also assisted in making the instrumental adjustments and the observations. Photographs of the check field were secured on the evening of September 19th to be used in case the evening of the 20th should be cloudy. They were discarded when the weather of the 20th proved favorable, and another pair of plates exposed on the check field at

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[10] *Publ. Allegheny Obs.*, 3, 63, 1914.

$7^h\ 45^m$ on the evening before the eclipse, and left undisturbed in the telescope, was used for the first pair of eclipse photographs. The roof of the observing house was opened about 15 minutes before totality; a small auxiliary finder, set on the crescent of the Sun, helped to point the telescope, while *β Virginis* became visible in the guiding telescope only about 30 seconds before totality, just in time to complete the setting. The image of the guiding star seemed steady and of good definition throughout totality. The first exposure of 2 minutes was started 10 seconds after the beginning of totality; 50 seconds were required to change the plate holders and steady the telescope from the resulting vibrations. The second pair of plates with an exposure of 2 minutes 5 seconds, stopped 10 seconds before the end of totality, received the impression of the check field on the evening of the eclipse day.

The night temperatures (70°5 to 72°5) at Wallal recorded during the exposures on the check field are very close to those of Tahiti; the temperature in the observing house during totality was about 8° higher (80°0 to 78°5) with a drop of 1°5; the humidity of the air, however, was very low at Wallal during the day and the evening.

Development and Quality of Star Images

In preparation for the eclipse a series of experiments was made to test different developers and different development times in their effects in bringing out the faintest stars on plates with a fogged background (photographs with Crossley reflector of star fields near the full Moon). No doubt was left but that a slow developer is more favorable than a rapid developer, and that the duration should not be much less than that of full development; underdevelopment, though diminishing the fogging of the background, also causes a considerable loss of fainter star images. Rodinal developer diluted 1:50 was selected; all the developing at Tahiti and Wallal had to be done at night and the temperature of the developer was kept close to 70°. At Wallal cooling by evaporation (wrapping the bottles in wet cloth) had to be resorted to.

The Tahiti plates were developed for 10 minutes. At Wallal some bromide of potassium was added and the duration was varied between 5 and 15 minutes. There is a strong psychological tendency to shorten the development when the corona is gaining in intensity so rapidly and when the background of the plate is darkening. After fixing the plate, however, the fogging is generally found much less serious than expected. A rule was therefore set up to extend the development at least 5 times longer than it took the most intense part of the corona to appear. After two plates (CD22 and AB17), developed according to this rule, had been fixed and examined, this factor was even increased to 10 or 12 times (CD23 and AB18). Despite heavier fogging the longer developed plates show on the average a few more measurable star images.

The corona is strong on all plates and its traces extend to about 1¼° from the Sun's center (see outline on Fig. 1) where the background becomes apparently uniform. The faintest star with a measurable image is of the photographic magnitude 10.8, while in the denser part of the corona (within 30′ from the Sun's limb) stars fainter than 9.5 proved very difficult and could be measured only on a few plates.

The star images are generally round and symmetrical, but not as sharp and well defined as on the Tahiti photographs; the fainter stars, especially, appear rather fuzzy and diffuse. It is hardly conceivable that this was produced by a change in focus, which should necessarily have been accompanied by a loss in faint stars. A more adequate explanation seems to be given by the well known fact, that star images on a fogged background become diffused by "creeping." Perhaps the "seeing" during totality may also have had some influence.

The method of measuring as many star images as possible, even faint and poor ones, and of employing a system of weights to take account of their different quality, seemed to make the best use of the available material. During the measures the observers estimated the quality of the image. The weight attributed to it depended entirely on this estimate, according to the following scale, which is in close agreement with the weight system used at the Allegheny Observatory for the parallax photographs:

Quality of image	Weight
Good	1
Fair	.7
Poor, faint, diffuse	.4
Very poor, very faint, very diffuse	.25

Measurement of Plates

From the eight Tahiti plates four were selected to be compared with the four eclipse photographs. In one of the comparison plates (AB10), however, a crack occurred after completing the right ascension measures and another plate (AB9) had to be substituted before the declination measures were made.

To measure the star images differentially an intermediate plate, taken through the glass, was used, following in this the example of the Greenwich expedition of 1919. This intermediate plate had been obtained at Tahiti with objective CD and 4 minutes' exposure; its star images are remarkably sharp and well exposed even for the faintest stars measured. Eclipse plates as well as night comparison plates were measured by placing them film to film with this intermediate plate, clamping the two plates tightly together by three clamps so that corresponding images fell together with a small offset. As objective AB has a slightly larger focal length, the plates taken with it differ from the intermediate plate in scale, and the distances between corresponding images were somewhat larger for stars near the edge of the plate; in no case, however, did they exceed 2 mm. This cannot introduce any error, since the eclipse plates and the night comparison plates were placed in exactly the same position with respect to the intermediate plate. The first three pairs of plates of Table I were measured independently by Campbell and Trumpler, the last one only by Trumpler. The measurement of each plate comprised four series:

(1) Difference of R.A. (Δx) "direct" : R.A. increasing toward the right hand.
(2) Difference of R.A. "reversed" : R.A. increasing toward the left hand.
(3) Difference of Decl. (Δy) "direct."
(4) Difference of Decl. "reversed."

All the "direct" measures were made with the intermediate plate turned toward the observer and measured through the glass; in the "reversed" measures the eclipse plate or night plate was measured through the glass.

For each series of measures the two plates were oriented in right ascension and declination for equinox 1922.0 by means of a few stars, for which the positions had been taken from the *Astr. Ges. Catalog.* With the filar micrometer of the microscope, magnifying about 15 times, the difference between the two corresponding images (of the eclipse or night plate and the intermediate plate) was measured by making two pairs of bisections on each image. Over 50,000 bisections of star images were thus made by the two observers during the course of the work. While in the eclipse field as many stars as possible were used, only 37 stars of the check field well distributed over the plate and of suitable brightness were selected. The stars of the two fields were measured intermingled without any distinction; two to six of the eclipse stars nearest to the Sun which are of the greatest importance in the present problem were measured at the beginning, in the middle and at the end of each series, to serve as a check on any possible changes as well as to increase the accuracy of their measures. The plates CD23 and CD17 had been measured in one direction (direct) at Broome (Western Australia) immediately after the eclipse; the reversed measures were later made at Mt. Hamilton.

Thanks are due to Miss Howe, Mrs. Campbell and Mrs. Trumpler for their help in recording the measures.

TABLE I

Data of the Plates Measured

Plate		Date 1922	Local M.T.	Exposure	Star field	Hour angle W.	Temp. F.	Barom. in.	
CD22	Wallal	Sept. 20	7^h $48^m.6$	2^m	Check field	1^h $37^m.4$	$72^{\circ}.5$	30.28	
		Sept. 21	1 31.2	2^m	Eclipse	1 37.8	79.2	30.26	
CD15	Tahiti	May 15	10 8.5	3^m	Eclipse	1 50.9	70	30.31	
		May 15	16 23.5	3^m	Check	1 52.0	69	30.32	
CD23	Wallal	Sept. 21	1 34.2	2^m5^s	Eclipse field	1 40.8	79.2	30.26	
		Sept. 21	7 47.6	2^m5^s	Check	1 40.2	70.5	30.31	
CD17	Tahiti	May 20	9 56.8	3^m	Eclipse	1 58.8	71	30.33	
		May 20	16 11.8	3^m	Check	1 59.9	70	30.31	
AB18	Wallal	Sept. 21	1 34.2	2^m5^s	Eclipse field	1 40.8	79.2	30.26	
		Sept. 21	7 47.6	2^m5^s	Check	1 40.2	70.5	30.31	
AB12	Tahiti	May 20	9 56.8	3^m	Eclipse	1 58.8	71	30.33	
		May 20	16 11.8	3^m	Check	1 59.9	70	30.31	
AB17	Wallal	Sept. 20	7 48.6	2^m	Check field	1 37.4	72.5	30.28	
		Sept. 21	1 31.2	2^m	Eclipse	1 37.8	79.2	30.26	
AB10	Tahiti	May 15	10 8.5	3^m	Eclipse	1 50.9	70	30.31	R.A.
		May 15	16 23.5	3^m	Check	1 52.0	69	30.32	
AB9	Tahiti	May 12	10 17.2	3^m	Eclipse	1 47.7	74	30.31	Decl.
		May 14	16 25.4	3^m	Check	1 49.9	72	30.17	

(All photographs taken by Trumpler.)

REDUCTION OF MEASURES

Subtracting the Δx and Δy (mean of "direct" and "reversed" measures) of the night comparison plate from the corresponding measures of the eclipse plate, we obtain the differences eclipse plate minus night plate (E — N) expressed in revolutions of the micrometer screw; the intermediate plate is thus completely eliminated. The screw value was determined repeatedly during the measuring period by means of two pairs of stars (98–99 and 102–103). Another method of evaluating this constant was to read on the setting scales how many mm. the microscope had to be shifted to make a star image move over an interval of 20 or 30 revolutions of the screw. Combining this with the known scale value of the plate (45″.075 per mm. for objective AB; 45″.30 for CD) the screw value in seconds of arc was obtained. Both methods gave satisfactory agreement: 7″.18 was used for plates CD22 and CD23; 7″.30 for AB18; 7″.32 for AB17.

The observed (E — N) were then corrected for the effects of proper motion and annual parallax of the stars, differential refraction and aberration, and inclination of the plate to the optical axis. Terms of the second order in x and y had to be included in these corrections. Ten stars of the eclipse field and three of the check field had determined proper-motions of sensible amount. One star (*β Virginis*) has a measured parallax and for three other stars hypothetical parallaxes derived from their spectral classes and proper-motions were taken into account.

For the check field a reduction formula:

$$\left.\begin{aligned}\Delta x(E-N)&=a+bx+cy+dx^2+exy+fy^2\\ \Delta y(E-N)&=a'+b'x+c'y+d'x^2+e'xy+f'y^2\end{aligned}\right\}\ \text{(12 constants)}$$

containing all terms of the second order was first used and the plate constants a, b, . . . a′, b′ . . . were determined by least squares solutions. It was, however, found that in all cases the second order terms could be confined to those produced by an error in the inclination of the plate to the optical axis:

$$f=0,\ d'=0,\ d=e'=p,\ e=f'=q.$$

The further condition that the scale and orientation constants of both coördinates be the same:

$$a=b'=r,\ c=-b'=s$$

was satisfied for the two plates CD22 and CD23. For AB17 the two coördinates, of course, had to be treated separately because different comparison plates had been used in the two coördinates. For AB18 a small change in the adjustment of the microscope between the R.A. and Decl. measures was sufficient explanation of the non-fulfillment of this condition. The final reduction of the check field was therefore made with the following simplified formulae:

$$\begin{array}{l}\text{CD22}\\ \text{CD23}\end{array}\left\{\begin{aligned}\Delta x&=a+rx+sy+px^2+qxy\\ \Delta y&=a'-sx+ry+pxy+qy^2\end{aligned}\right\}\ \text{(6 constants)}$$

$$\text{AB18}\left\{\begin{aligned}\Delta x&=a+bx+cy+px^2+qxy\\ \Delta y&=a'+b'x+c'y+pxy+qy^2\end{aligned}\right\}\ \text{(8 constants)}$$

$$\text{AB17}\left\{\begin{aligned}\Delta x&=a+bx+cy+px^2+qxy\\ \Delta y&=a'+b'x+c'y+p'xy+q'y^2\end{aligned}\right\}\ \text{(10 constants)}$$

and a second set of least squares solutions supplied the numerical values of the constants.

From the resulting residuals in x and y the radial component in the direction away from the plate center was calculated. The mean radial residuals for all the plates measured by each observer are plotted in Fig. 3 as a function of the star's angular distance from the plate center.

It seemed desirable to effect the reduction of the eclipse field without determining too many constants from the measures themselves, for these constants would necessarily be mixed up with the light deflections; it was desirable also to avoid making any *a priori* assumptions about the light deflections and about the law according to which they diminish with increasing angular distance of the stars from the Sun's center. The first point was facilitated by the way in which the exposures on the check field had been made; this allowed the adoption for the eclipse region of the second order terms determined by the solution of the check field. The second desideratum could be secured, thanks to the large field of the plate, by using the stars more distant than 2° from the Sun's center (28 to 38) as reference stars for the determination of the linear correction terms (zero point, orientation and scale). Neglecting the light deflections of these stars (0″.14 to 0″.23 according to Einstein's theory) would cause a sensible error only in the scale value thus determined. A revision of this correction will have to be made later, when the law of light deflection has been established.

The linear plate constants of the eclipse field were obtained by least squares solutions according to Turner's formula:

$$\left.\begin{aligned}\Delta x&=a+bx+cy\\ \Delta y&=a'+b'x+c'y\end{aligned}\right\}\ \text{(6 constants)}$$

The agreement of the scale and orientation constants of both coördinates

$$b=c'=r,\ c=-b'=s$$

was satisfactory for the plates CD22 and CD23 for which another solution, made with the formula:

$$\left.\begin{aligned}\Delta x&=a+rx+sy\\ \Delta y&=a'-sx+ry\end{aligned}\right\}\ \text{(4 constants)}$$

was finally used. For the plates AB17 and AB18 the six-constant formula had to be retained for the reasons stated above in describing the reduction of the check field.

RESULTS

The residuals, after application of these plate corrections, represent the observed star displacements due to light deflection. We shall call them the *relative* displacements, because they are derived by comparing the stars near the Sun with the reference stars of the outer portions of the plate, and the plate constants are so determined as to make the average displacements of the reference stars zero. To convert the relative values into absolute ones an additional scale correction is needed.

In forming the means of the results of both observers for each plate the weight of any measure made only by one observer (plate AB17) was reduced

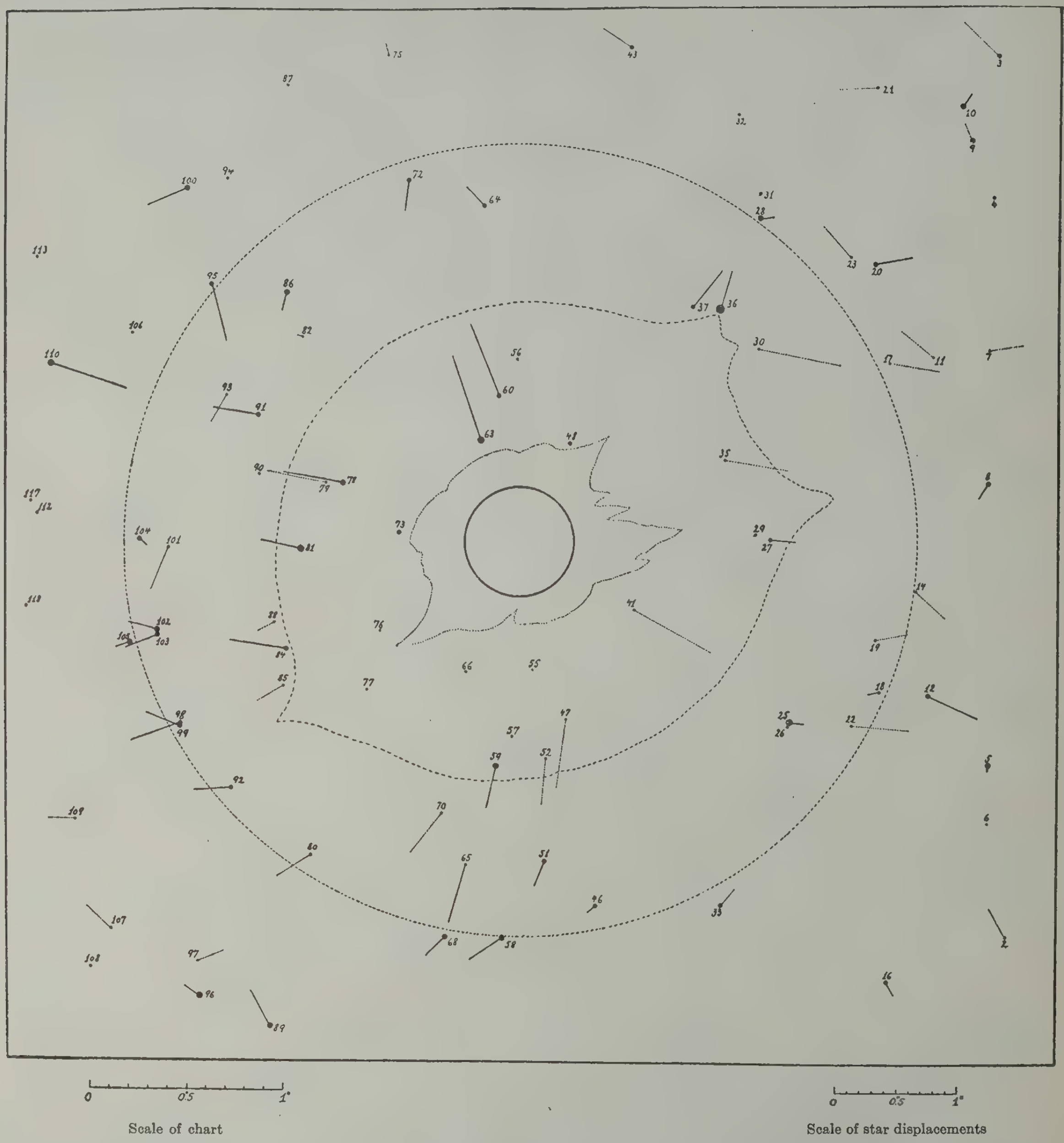

Fig. 1. Star chart of the total solar eclipse of Sept. 21, 1922, containing the 92 stars actually measured. The observed relative displacements are marked by a full line for weights 2.0 to 3.9, by a dotted line for weights 1.0 to 2.0, displacements of smaller weight are omitted. The dotted circle is of 2° radius and gives the inner limit of the reference stars, for which the average displacement has been made zero. The outline of the brighter parts of the corona as well as the limit of the faintest traces of coronal light is drawn in. The border line represents the edge of the plate.

by multiplication with 0.9. This factor was derived according to the theory of errors from the accidental "measuring error" and the "plate error" common to the measures of both observers. The four plates were then combined according to their weights. The resulting mean values of the observed relative displacements are given in TABLE II (seventh and eighth columns) together with their total weights (ninth column); they are also plotted, 2250 times enlarged, in Fig. 1. A remarkably large residual is shown by star 110; perhaps this may be accounted for by the situation of the star close to the edge of the plate.

TABLE II

OBSERVED RELATIVE STAR DISPLACEMENTS

No.	B. D.	Phtgr. magn.	X	Y	Distance fr. Sun.	Ecl.—Night		Weight	Radial comp. D_1	Corr. rad. comp. D_2	Theory
						Δx	Δy				
2	−0° 2479	10$^{\mathrm{m}}$4	−2.00	−1.58	2.55	+ ″12	+ ″24	1.13	− ″24	− ″26	−″06
3	+3 2544	9.2	−1.92	+1.99	2.76	+ .29	+ .28	1.5	.00	.00	−.08
4	+3 2545	10.1	−1.91	+1.42	2.38	+ .47	+ .33	.66	− .18	− .23	−.03
5	+0 2831	8.3	−1.92	− .88	2.11	+ .01	− .06	3.9	+ .02	− .04	+.01
6	−0 2482	10.4	−1.92	−1.12	2.22	− .15	+ .16	.87	+ .05	.00	−.01
7	+2 2474	10.3	−1.90	+ .80	2.06	− .28	+ .05	1.27	+ .28	+ .24	+.02
8	+1 2608	9.8	−1.90	+ .26	1.91	+ .08	− .12	2.46	− .10	− .13	+.04
9	+3 2548	9.2	−1.82	+1.65	2.46	+ .06	+ .14	1.5	+ .05	+ .02	−.04
10	+3 2549	8.7	−1.78	+1.79	2.52	− .06	+ .11	2.46	+ .12	+ .11	−.05
11	+2 2477	10.0	−1.67	+ .77	1.84	+ .26	+ .21	1.61	− .15	− .18	+.05
12	+0 2833	9.6	−1.67	− .60	1.77	− .41	− .19	2.88	+ .45	+ .44	+.07
14	+1 2610	10.3	−1.61	− .18	1.62	− .24	− .22	1.79	+ .26	+ .29	+.10
16	−0 2490	9.3	−1.52	−1.77	2.34	− .06	− .11	2.31	+ .12	+ .08	−.03
17	+2 2480	10.2	−1.49	+ .74	1.66	− .42	− .06	1.94	+ .35	+ .36	+.09
18	+0 2836	10.0	−1.47	− .59	1.58	+ .10	− .02	2.39	− .09	− .07	+.11
19	+0 2837	10.4	−1.45	− .38	1.50	− .26	+ .07	1.06	+ .23	+ .28	+.13
20	+2 2481	9.3	−1.43	+1.14	1.83	− .31	+ .07	2.73	+ .28	+ .26	+.06
21	+3 2553	10.4	−1.43	+1.86	2.34	+ .36	− .02	1.12	− .23	− .25	−.03
22	+0 2839	10.4	−1.36	− .73	1.55	− .47	− .04	1.39	+ .43	+ .45	+.12
23	+2 2483	10.2	−1.33	+1.17	1.77	+ .23	+ .25	1.06	− .01	− .01	+.07
25	+0 2843	6.9	−1.11	− .72	1.33	− .12	− .01	3.9	+ .11	+ .16	+.17
26		10.8	−1.10	− .74	1.33	− .30	+ .12	.72	+ .18	+ .24	+.17
27	+1 2617	9.4	−1.02	+ .02	1.02	− .21	− .02	2.61	+ .21	+ .32	+.28
28	+3 2560	8.2	− .96	+1.32	1.63	− .12	+ .01	3.9	+ .08	+ .09	+.10
29	+1 2618	10.2	− .96	+ .04	.97	+ .01	− .02	1.27	− .01	+ .10	+.31
30	+2 2486	10.4	− .96	+ .79	1.24	− .67	− .13	1.76	+ .43	+ .51	+.20
31	+3 2561	10.2	− .96	+1.42	1.71	+ .01	− .02	1.56	− .02	− .03	+.08
32	+3 2562	10.3	− .87	+1.74	1.95	− .01	+ .24	.44	+ .22	+ .19	+.04
33	−0 2498	9.7	− .84	−1.47	1.69	− .11	+ .14	2.46	− .06	− .07	+.09
35	+1 2619	10.1	− .83	+ .34	.90	− .51	− .09	1.31	+ .44	+ .56	+.34
36	β Virginis	4.3	− .80	+ .95	1.24	− .09	+ .32	2.73	+ .30	+ .38	+.20
37	+2 2490	9.7	− .69	+ .96	1.18	− .23	+ .29	3.18	+ .37	+ .46	+.22
41	+1 2621	10.0	− .47	− .27	.54	− .64	− .35	1.31	+ .73	+ .80	+.64
43	+3 2566	9.1	− .43	+2.01	2.06	+ .24	+ .15	2.58	+ .10	+ .05	+.02
46	−0 2501	9.7	− .33	−1.48	1.52	+ .07	− .05	2.88	+ .03	+ .07	+.12
47	+0 2853	10.2	− .20	− .72	.75	+ .07	− .56	1.2	+ .52	+ .63	+.44
48	+1 2623	9.4	− .20	+ .40	.44	+ .27	+ .68	.22	+ .47	+ .48	+.80
51	−0 2507	9.4	− .12	−1.30	1.30	+ .08	− .21	3.6	+ .20	+ .28	+.18
52	+0 2854	10.2	− .12	− .88	.89	+ .03	− .38	1.2	+ .37	+ .49	+.34
55	+0 2855	10.4	− .06	− .52	.52	−1.18	− .58	.44	+ .72	+ .74	+.67
56	+2 2492	10.6	+ .02	+ .74	.74	− .40	+ .69	.55	+ .68	+ .77	+.44
57	+0 2856	10.6	+ .02	− .79	.79	− .09	+ .53	.66	− .53	− .45	+.41
58	−0 2510	8.4	+ .05	−1.62	1.62	+ .26	− .18	3.75	+ .19	+ .21	+.10
59	+0 2858	8.3	+ .08	− .91	.91	+ .07	− .35	3.75	+ .36	+ .46	+.33
60	+2 2493	9.4	+ .09	+ .59	.60	+ .24	+ .58	2.06	+ .61	+ .69	+.57

TABLE II (*Continued*)

No.	B. D.	Phtgr. magn.	X	Y	Distance fr. Sun.	Ecl.—Night Δx	Δy	Weight	Radial comp. D_1	Corr. rad. comp. D_2	Theory
63	+1° 2628	$7^{\mathrm{m}}3$	+ .16	+ .41	.44	+ ″24	+ ″68	3.9	+ ″72	+ ″76	+″81
64	+3 2572	9.1	+ .16	+1.36	1.37	+ .15	+ .15	3.75	+ .17	+ .23	+.16
65	−0 2511	10.3	+ .20	−1.32	1.33	+ .14	− .49	2.13	+ .51	+ .58	+.17
66	+0 2859	10.2	+ .21	− .53	.57	− .78	− .90	.25	+ .55	+ .64	+.62
68	−0 2512	8.8	+ .28	−1.62	1.64	+ .16	− .16	3.48	+ .19	+ .20	+.10
70	+0 2860	10.2	+ .30	−1.11	1.14	+ .26	− .33	1.94	+ .39	+ .49	+.24
72	+3 2576	9.4	+ .47	+1.46	1.54	+ .04	− .25	2.31	− .23	− .19	+.12
73	+1 2631	9.6	+ .49	+ .03	.49	− .14	− .47	.69	− .17	− .12	+.73
75	+3 2577	10.1	+ .56	+1.97	2.05	+ .03	+ .14	1.05	+ .14	+ .10	+.02
76	+0 2864	10.5	+ .56	− .37	.67	+1.18	−1.08	.22	+1.58	+1.64	+.50
77	+0 2865	10.6	+ .61	− .61	.86	+ .47	+ .16	.44	+ .22	+ .30	+.36
78	+1 2633	8.4	+ .72	+ .23	.76	+ .49	+ .09	3.75	+ .49	+ .60	+.43
79	+1 2635	10.3	+ .79	+ .23	.82	+ .48	+ .09	1.39	+ .49	+ .60	+.39
80	−0 2515	10.3	+ .83	−1.29	1.54	+ .27	− .18	1.86	+ .30	+ .33	+.12
81	+1 2636	7.5	+ .89	− .04	.89	+ .32	+ .07	3.9	+ .32	+ .43	+.34
82	+2 2498	10.3	+ .89	+ .82	1.21	+ .06	+ .01	1.86	+ .05	+ .14	+.21
84	+0 2870	9.6	+ .94	− .45	1.04	+ .47	+ .07	2.88	+ .39	+ .49	+.28
85	+0 2872	10.2	+ .95	− .60	1.12	+ .21	− .13	1.2	+ .25	+ .34	+.24
86	+2 2499	8.0	+ .96	+1.00	1.38	+ .04	− .16	3.9	− .09	− .02	+.16
87	+3 2583	10.4	+ .97	+1.84	2.08	+ .32	+ .15	.87	+ .28	+ .23	+.01
88	+0 2874	10.0	+ .99	− .34	1.04	+ .13	− .07	1.71	+ .15	+ .26	+.28
89	−1 2600	8.3	+ .99	−2.00	2.23	+ .16	+ .29	3.18	− .19	− .24	−.01
90	+1 2637	10.4	+1.06	+ .26	1.09	+ .22	+ .10	.73	+ .24	+ .35	+.26
91	+2 2501	9.7	+1.07	+ .50	1.18	+ .39	+ .05	2.28	+ .37	+ .47	+.22
92	+0 2875	9.6	+1.16	−1.02	1.55	+ .30	− .02	2.88	+ .24	+ .27	+.12
93	+2 2502	10.0	+1.20	+ .58	1.33	+ .11	− .23	1.68	.00	+ .06	+.17
94	+3 2586	10.5	+1.21	+1.46	1.90	+ .75	− .12	.77	+ .38	+ .35	+.05
95	+2 2505	9.6	+1.27	+1.03	1.64	− .13	− .48	2.81	− .40	− .39	+.10
96	−0 2520	7.8	+1.28	−1.88	2.28	+ .13	+ .08	3.9	+ .01	− .04	−.02
97	−0 2521	10.3	+1.29	−1.74	2.17	− .21	+ .09	1.35	− .20	− .25	.00
98	+0 2877	9.3	+1.37	− .76	1.57	+ .42	− .15	3.0	+ .44	+ .46	+.11
99	+0 2878	9.0	+1.37	− .77	1.57	+ .29	+ .11	3.33	+ .20	+ .23	+.11
100	+3 2588	9.5	+1.37	+1.42	1.98	+ .33	− .15	2.55	+ .12	+ .08	+.03
101	+1 2639	10.0	+1.43	− .04	1.43	+ .13	− .35	2.09	+ .14	+ .19	+.15
102	+0 2880	8.2	+1.47	− .38	1.52	+ .24	+ .06	3.75	+ .21	+ .26	+.13
103	+0 2881	9.5	+1.47	− .40	1.52	+ .26	− .11	2.88	+ .28	+ .32	+.13
104	+1 2641	9.3	+1.55	− .01	1.55	− .06	− .06	3.03	− .06	− .03	+.12
105	+0 2883	8.8	+1.58	− .43	1.64	+ .12	− .04	3.03	+ .13	+ .14	+.10
106	+2 2507	10.4	+1.59	+ .83	1.80	− .06	− .41	.47	− .24	− .26	+.06
107	−0 2524	10.2	+1.65	−1.61	2.30	+ .25	+ .23	1.3	+ .02	− .02	−.02
108	−0 2526	10.2	+1.73	−1.77	2.47	+ .43	+ .15	.87	+ .19	+ .15	−.05
109	−0 2527	10.4	+1.80	−1.16	2.14	+ .23	.00	1.16	+ .19	+ .14	.00
110	+2 2509	7.8	+1.92	+ .70	2.05	− .64	− .21	3.75	− .67	− .72	+.02
112	+1 2645	10.0	+1.97	+ .09	1.98	− .79	+ .43	.76	− .76	− .80	+.03
113	+2 2510	10.1	+1.98	+1.13	2.28	− .52	− .11	.66	− .51	− .54	−.02
117	+1 2647	10.1	+2.00	+ .14	2.01	.00	− .28	.33	− .02	− .07	+.02
118	+1 2648	9.9	+2.01	− .29	2.03	− .96	+ .96	.25	−1.09	−1.13	+.02

The first two columns of TABLE II designate the star; the third contains the photographic magnitudes, derived from diameter measures of the star images and based on the photographic magnitude scale of the *Henry Draper Catalogue*. The next three columns (4 to 6) give the rectangular coördinates of each star and its distance from the Sun's center expressed in units of 100 mm. = 4508″. From the mean observed relative displacements Δx and Δy in columns 7 and 8, the component in the radial direction D_1, (positive if away from the Sun) was calculated (column 10). This observed radial component represents the effect of light deflection and may be compared with the corresponding values predicted by Einstein's theory (last column of TABLE II). The theoretical values given are not the full predicted star displacements, but the *relative* displacements derived from them by the scale correction: —″.079 d (d = distance from Sun's center). This coefficient is the mean of the scale corrections of the four plates as obtained from the least squares solutions mentioned below.

Arranging the stars according to their distance from the Sun's center the group means of TABLE III were formed:

TABLE III

GROUP MEANS OF OBSERVED RELATIVE RADIAL DISPLACEMENTS

Group	Stars	Weight	Mean dist. from Sun	Obs. rad. displ.	Corrected rad. displ.	Theory
1	8	9.09	0°.64	+″.64	+″.69	+″.70
2	11	19.42	1.06	+.35	+.46	+.37
3	10	20.15	1.40	+.30	+.39	+.24
4	8	22.41	1.66	+.16	+.22	+.17
5	9	21.10	1.90	+.17	+.21	+.13
6	8	24.67	2.00	+.15	+.17	+.11
7	11	21.32	2.22	+.08	+.08	+.08
8	13	21.37	2.55	−.09	−.14	+.02
9	14	22.78	2.97	−.04	−.08	−.03

Reserving the data in the next to the last column (corrected rad. displ.) of TABLES II and III for comment on a later page, one may note here that the *observed* radial displacements given in these tables are in remarkably good agreement with the values predicted on the basis of Einstein's theory. Even the stars between 1°.25 and 2°.25 from the Sun's center, lying entirely outside of any trace of the corona, show the light deflection well marked, an effect that would be hard to explain by an extended solar atmosphere.

A graphical representation of the coincidence between the observed and the predicted light deflections is given in Fig. 2, where the observed radial displacement D_1 of each star is plotted as a function of the star's angular distance from the Sun's center. Stars with weights 2.0 to 3.9 are marked by large dots, those with weights 1.0 to 2.0 by small dots, stars with weight below 1.0 being omitted. The group means (D_1) of TABLE III are joined by the broken line, while the dotted curve shows the prediction by Einstein's theory. A new base line B has been constructed illustrating the scale correction needed to convert the relative displacements into absolute ones. All plots if measured vertically from base line B give absolute displacements. As far as it is referred to the original base A, the figure represents the relative radial displacements actually observed and is independent of any assumption about the light deflection (except that it be radial and independent of the position angle of the star).

Adopting Einstein's prediction that the displacements are inversely proportional to the distance d from the Sun's center, and keeping in mind that the scale value needs correction, the radial displacements (Δr) observed are represented by a formula

$$\Delta r = \alpha d + \beta \frac{R}{d}$$

where:

α = correction of scale value
β = light deflection at Sun's limb
R = radius of Sun's disk = 0°.2661.

For each plate and each set of measures α and β were determined from the measured radial displacements of all stars by least squares solutions.

TABLE IV

LIGHT DEFLECTION AT THE SUN'S LIMB

Plates	Campbell	No. of stars	Trumpler	No. of stars	Plate mean
CD22—CD15	*1″.72±″.32	62	*1″.88±″.27	69	1″.80
CD23—CD17	1.35±.22	77	*1.62±.22	81	1.48
AB18—AB12	*1.78±.22	80	*1.91±.19	84	1.85
AB17—AB10/9			1.76±.22	85	1.76 (weight .9)
Mean for each observer	1″.60±″.14		1″.78±″.11		
			Mean from four plates		1″.72±″.11
			Einstein's predicted value		1″.745

---

* These five values, very slightly modified, were the only ones available when the preliminary announcement of our results for the Einstein eclipse problem was made through the press associations and otherwise, on April 11, 1923. At that date we had also determined from measures of the check-region star images, that any corrections suggested or demanded by existing small plate errors could not operate to diminish any of the five values of the Einstein coefficient.

The agreement with the prediction is again very satisfactory, only one of the seven results differing from it by more than its probable error. The plate means were formed by giving equal weight to both observers. The means for each observer are based on the weights of the separate least squares solutions. When taking the mean of the four plates, the first three plates received weight 1, the last plate, measured only once, weight 0.9 (see page 48).

For every plate the measures of the two observers were reduced independently, even as to the weighting of the stars according to the estimates of each observer, and as to all the plate constants determined from the measures. No measures once entered in the observing book were rejected during the reductions, except when a remark suggesting that this be done had been made during the measures (two cases), or if the star image on one of the plates was within 10 mm. from its edge, and further in two cases of measures of very faint and uncertain images, giving residuals exceeding 1″.5.

The star field was further divided into four quadrants so situated that the Sun's equator passed through the middle of two of the quadrants and the Sun's axis of rotation through the middle of the other two. For the stars of each quadrant a separate least squares solution with the formula of page 51 was made, using the mean radial displacements D_1 of Table II.

Quadrant	No. of stars	Light deflection at Sun's limb
Preceding Sun's equator	24	1″.61 ± ″.28
Following Sun's equator	29	1.68 ± .25
At Sun's North pole	18	1.76 ± .26
At Sun's South pole	21	1.73 ± .24
Mean of equatorial quadrants	53	1″.63 ± ″.15
Mean of polar quadrants	39	1.76 ± .18

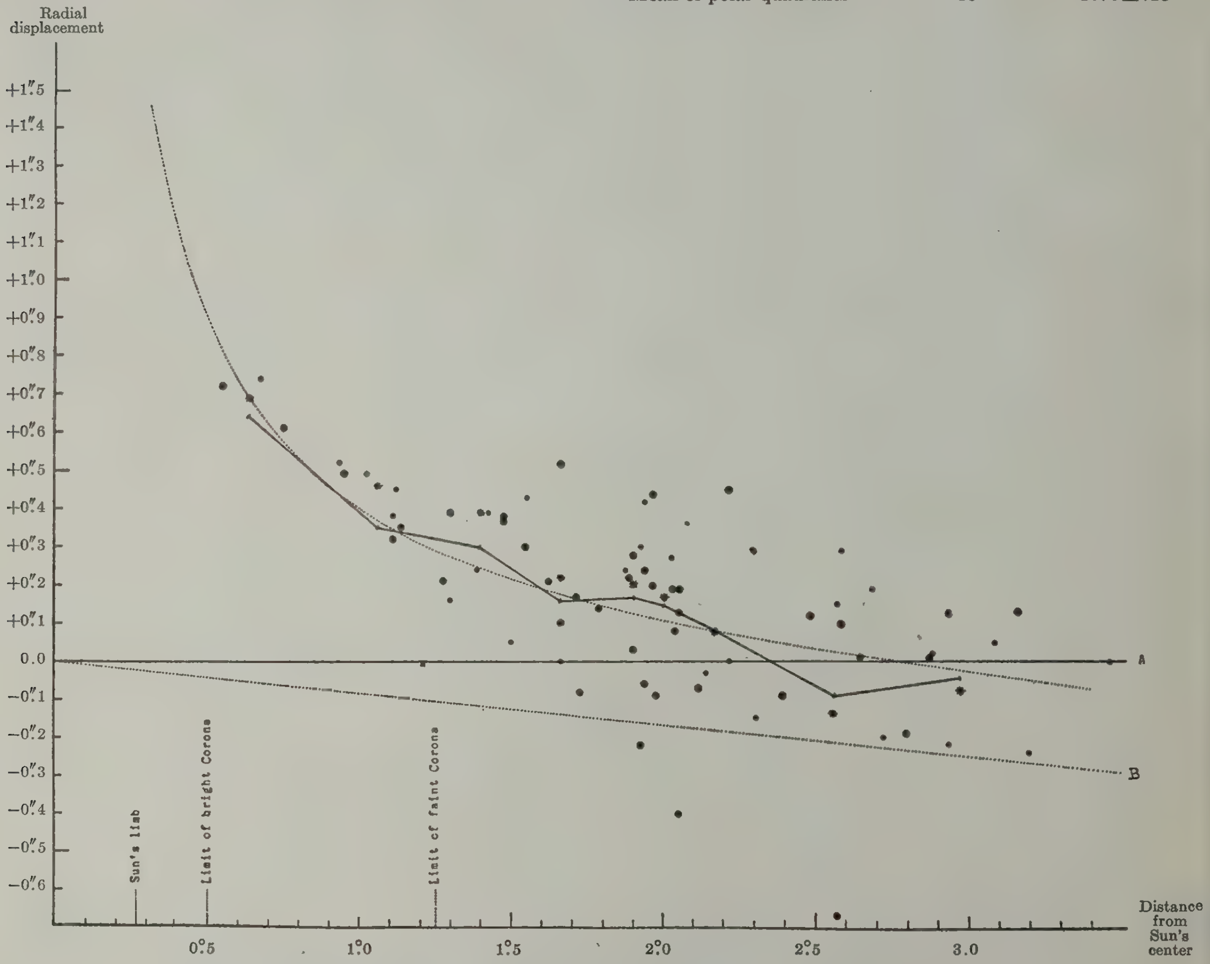

Fig. 2. Observed radial displacements as a function of the star's angular distance from the Sun's center. Large dots represent stars with weights 2.0 to 3.9, small dots those with weights 1.0 to 2.0; stars of smaller weight are omitted. The broken line connects the group means of the observed radial displacements, the asterisks mark the group means of the observations corrected on the basis of the residuals of the check stars. The dotted curve gives the values predicted by Einstein's theory. If the displacements are measured vertically from base line B they are absolute, if measured from base line A they are relative to the reference stars (as actually measured).

The agreement of the four quadrants is better than we should expect from the probable errors. This shows that the light deflections are practically identical in all position angles, and it proves also that the determination of the plate constants is very satisfactory and can have no appreciable influence on our results. The slight difference between the light deflections at the Sun's equator and those at the poles is probably accidental; at least it is well within the limits of the errors of observation.

The probable errors of a differential measure (E — N) of weight 1 (good) on one pair of plates are on the average:

	Campbell	Trumpler
Check field	±″19	±″16
Eclipse field, radial	±.20	±.19
Eclipse field, pos. angle	±.18	±.18

These data are derived from the residuals of all the stars. Comparing the radial residuals of both observers for the eclipse stars of two plates, the "accidental measuring error" is found to be only ±″08. From this we conclude that the preponderant part of the above probable errors is an actual "plate error" in the star images, not reduced by increasing the number of measures. The effects of the corona and of the fogging of the sky background, not only in increasing the difficulty of the measures, but probably also in influencing the grouping of the silver grains in the star images, have to be considered when judging these probable errors.

The probable error is slightly smaller in position-angle than in radial direction. The observations, therefore, give no evidence of star displacements in any other direction than radially away from the Sun's center, and the deviations from the radial direction shown by the observations plotted in Fig. 1 are entirely accounted for by the accidental errors of observation.

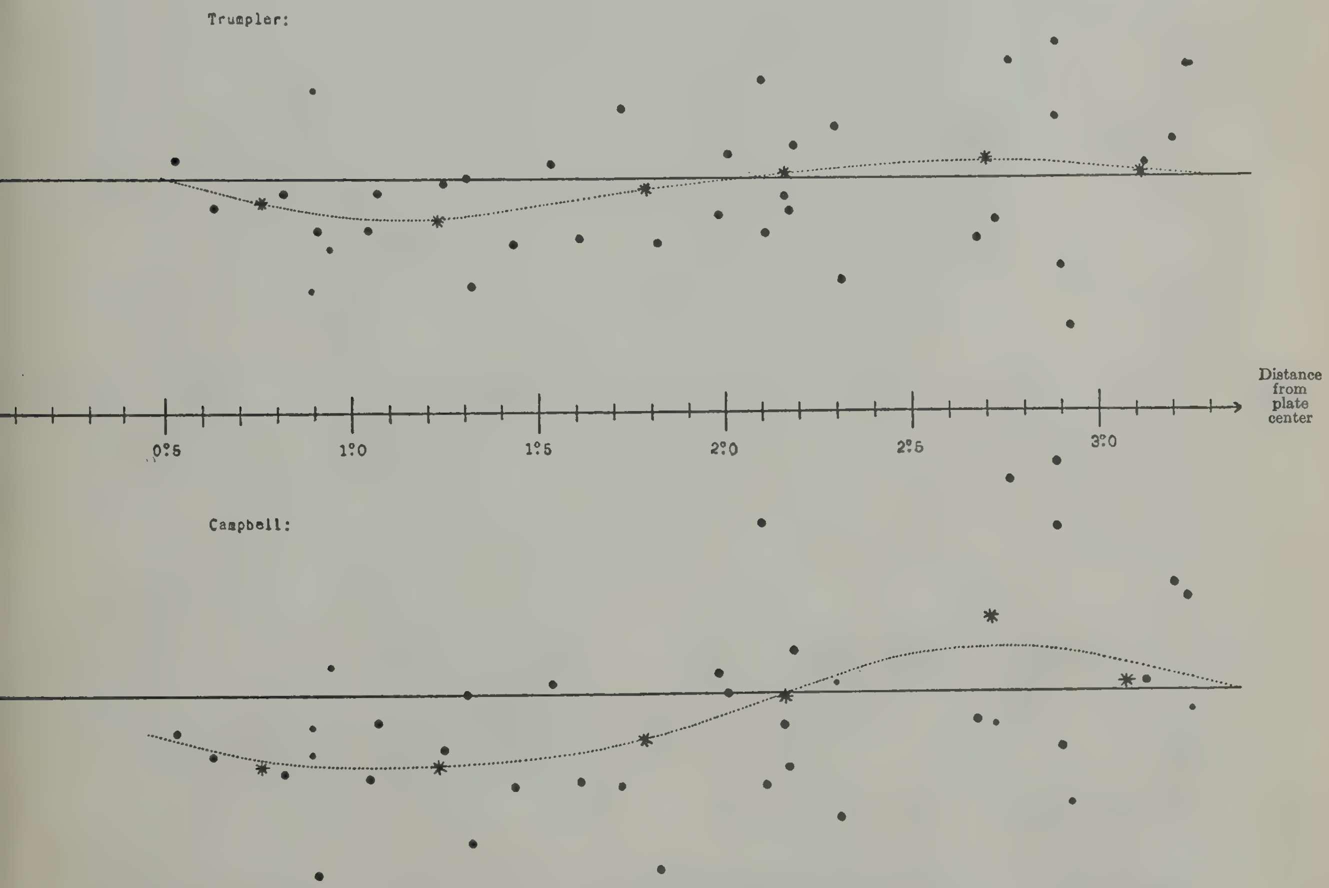

Fig. 3. Radial residuals of check stars as a function of their angular distance from the plate center. Large dots represent stars with weights larger than 2.0, small dots those with weights smaller than 2.0. The asterisks give the group means of the residuals; the dotted curves show the corrections derived therefrom and applied to the stars of the eclipse field.

We have still to examine the residuals of the check stars for the existence of any systematic errors that might have affected the observed light deflections. Arranging the check stars according to their distance from the plate center and forming group means of the radial components of the residuals we obtain the following table:

TABLE V

RADIAL COMPONENT OF RESIDUALS OF CHECK STARS

		Campbell			Trumpler		
Group	Stars	Weight	Dist. fr. center	Radial resid.	Weight	Dist. fr. center	Radial resid.
1	7	11.75	0°76	−″16	15.15	0°76	−″05
2	6	16.8	1.24	−.15	23.1	1.24	−.09
3	6	16.5	1.79	−.10	22.2	1.79	−.02
4	6	15.6	2.17	−.01	21.3	2.17	+.01
5	6	15.0	2.72	+.16	19.2	2.71	+.04
6	6	12.75	3.08	+.02	17.55	3.12	+.01

This table corresponds to TABLE III, except that the measures of the two observers are treated separately. In a similar way Fig. 3 is to be compared with Fig. 2. The large star displacements near the Sun found in the eclipse field have no counterpart in the check field and can therefore not have their source in any instrumental errors, nor can they be due to the peculiar method of measuring and reducing the plates. Some small systematic deviations in the check stars, however, are indicated for both observers, and if their causes affect the stars of the eclipse field in the same manner, our results for the light deflections will be too small.

There may be some doubt as to whether corrections based on the residuals of the check stars should be applied to the observed displacements of the eclipse stars. Temperature and other conditions during the eclipse were of course not identical with those prevailing at night when the check field was photographed; the check stars are also on the average a little brighter than the eclipse stars; and, finally, a part of the grouping in the residuals of the check stars may be accidental. On the other hand the most reasonable explanations of the observed deviations of the check stars seem to be offered by the sources of error mentioned on page 41 under 1, 2, and 3, which should have affected alike both star fields photographed on the same plate. The contraction of the photographic film during the process of drying, mentioned under 3, would explain the sign of the deviation. The fact that the two observers differ in its amount, rather suggests that a personal measuring error is involved. This personal difference is reflected in exactly the same way in the results of TABLE IV, where the light deflections measured by Campbell are consistently smaller than those by Trumpler; and the improvement in the agreement of the results of the two observers, achieved by the use of the corrections mentioned, is undoubtedly in their favor.

If such corrections, read from the dotted curves drawn in Fig. 3, are applied with opposite sign to the observed radial displacements D_1 of the eclipse stars, we obtain the "corrected" values D_2 of the column next to the last in TABLES II and III. The group means of D_2 are also represented in Fig. 2 by asterisks, and a new least squares solution with the formula of page 51, using the corrected data D_2 of TABLE II, gives for the deflection at the Sun's limb: 2″05.

This result is 17% in excess of the prediction, but it should be kept in mind that it is derived by extrapolation. A closer examination of the last two columns of TABLE III and of Fig. 2 shows that it is not the stars nearest to the Sun that differ in their corrected displacements from the theoretical values; it is only for the stars between one and two degrees distant from the Sun's center that the corrections have introduced a marked excess in light deflection (slightly indicated even in the original displacements D_1). If the corrections are justified, our observations suggest the existence of an effect additional to that of Einstein's theory. This additional effect should be small at the Sun's limb and rise gradually to a maximum of about 0″4 at 2° to 3° from the Sun's center, in order, when combined with a new determination of the scale value to agree with the corrected displacements D_2. It could then be considered as representing Courvoisier's "yearly refraction" in the immediate neighborhood of the Sun. It is however inadvisable to pursue this problem any further at the present moment, as the plates of the 5-foot cameras, with a larger field, will shortly supply material much better suited to its investigation.

W. W. CAMPBELL.
R. TRUMPLER.

May, 1923.

Issued July 5, 1923.

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ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 347

ELEMENTS AND OPPOSITION EPHEMERIS OF MINOR PLANET 1922 ND. (Y.O.3)

Minor Planet 1922 ND was discovered by Van Biesbroeck at the Yerkes Observatory on November 14, 1922. It was observed in November and December, but could not be found in January. An ephemeris based on elements by Einarsson and Shane enabled Van Biesbroeck to photograph the asteroid on February 3 and 4, after which no further observations were secured.

Since more accurate elements are desirable for prediction at the next opposition, a second orbit has been computed. For this purpose Van Biesbroeck has kindly sent us the following accurate positions based on measures of the Yerkes plates by himself and Struve.

		Gr. M. T.	α (1922.0)	δ (1922.0)
I	(1)	1922 Nov. 20.6882	1^{h} 42^{m} $09^{\mathrm{s}}57$	+9° 45′ 41″3
	(2)	Nov. 20.7042	1 42 09.10	9 45 36.0
II	(3)	" Dec. 15.6118	1 35 47.53	8 14 21.6
	(4)	1922 Dec. 20.6677	1 36 02.46	8 06 37.2
III	(5)	1923 Feb. 3.5426	1 58 29.61	9 11 24.1
	(6)	1923 Feb. 4.5694	1 59 21.39	9 15 03.7

Normal places corrected for aberration and parallax were found from these observations and are given below:

	Gr. M. T.	α (1922.0)	δ (1922.0)
I	1922 Nov. 20.6744	1^{h} 42^{m} $09^{\mathrm{s}}64$	9° 45′ 43″2
II	1922 Dec. 20.5521	1 36 02.52	8 06 36.7
III	1923 Feb. 4.5502	1 59 21.56	9 15 03.9

An accurate solution based on these normal places yielded the following elements:

ELEMENTS

Epoch	1922 Dec. 20.6521	
M	213° 42′ 18″	
ω	339° 08′ 59″	1922.0
Ω	213° 10′ 48″	
i	10° 47′ 08″	
e	0.085971	
μ	672″707	
P	5.27450 years	
log a	0.481454	

CONSTANTS FOR THE EQUATOR 1922.0

$x = r\,[9.997711] \sin(281° \; 51' \; 49''0 + v)$

$y = r\,[9.986305] \sin(190 \; 21 \; 30.1 + v)$

$z = r\,[9.427479] \sin(213 \; 37 \; 21.4 + v)$

The residuals are as follows:

	Δα cos δ	Δδ
(1)	−0″2	+0″4
(2)	+0.3	+0.3
(3)	−0.3	−2.2
(4)	+0.5	+2.5
(5)	+1.4	−1.4
(6)	−1.1	+1.4

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT

Gr. M. T.	α (1924.0)	δ (1924.0)
1923 Dec. 19.5	7^{h} 25^{m} 40^{s}	+7° 10′8
1923 Dec. 27.5	7 19 45	6 58.4
1924 Jan. 4.5	7 13 09	6 54.3
Jan. 12.5	7 06 18	6 58.7
1924 Jan. 20.5	6 59 42	+7 10.8

C. D. Shane.
Mary Lea Shane.

Berkeley Astronomical Department,
May, 1923

PRELIMINARY ELEMENTS OF MINOR PLANET 1922 MZ (Y. O. 5)

Minor Planet 1922 MZ was discovered by Van Biesbroeck on November 23, 1922. Five observations were secured in November and December, but it could not be found in January. An orbit was computed from the observations of November 24, December 15, and December 22 and an ephemeris was forwarded to Van Biesbroeck. Owing to the proximity of the Moon, and to cloudy weather he was unable to observe the asteroid during February, but on March 10 it was rediscovered about 20 minutes of arc from the predicted position.

The following observations have been furnished by Van Biesbroeck:

		α (1925.0)	δ (1925.0)
1922	Nov. 23.836	4ʰ 37ᵐ 18ˢ	+36° 38′.1
	Nov. 24.769	36 12	36 38.1
	Dec. 15.840	12 22	35 48.8
	Dec. 22.707	06 27	35 17.8
1923	Mar. 10.595	4 42 26	+31 16.7

The preliminary elements and constants for the equator 1922.0 are as follows:

ELEMENTS

T	1922 May 17.835	
ω	12° 25′.0	1922.0
Ω	353° 25.8	
i	8° 43.1	
e	0.19713	
μ	827″.48	
P	4.289 years	
$\log a$	2.6393	

CONSTANTS FOR THE EQUATOR 1922.0

$$x = r\,(9.99993)\sin(95°\ 55'.4 + v)$$
$$y = r\,(9.92791)\sin(\ 5°\ 18.0 + v)$$
$$z = r\,(9.72575)\sin(\ 7°\ 30.4 + v)$$

RESIDUALS

		Δα cos δ	Δδ
1922	Nov. 23.836	+0′.1	−0′.2
	Nov. 24.769	+0.2	−0.2
	Dec. 15.840	0.0	0.0
	Dec. 22.707	0.0	0.0
1923	Mar. 10.595	−21.0	+4.4

C. D. Shane.
J. A. Pearce.

Berkeley Astronomical Department,
1923 March 16

OBSERVATIONS OF COMET 1922 *c* (Baade)

Date 1922	Gr. M. T.	Star	No. of Comp.		Comet-Star Δα	Comet-Star Δδ	Comet's Apparent α	Comet's Apparent δ	Log ρΔ α	Log ρΔ δ	Observer
Oct. 23	16ʰ 27ᵐ 48ˢ	1	10	10	+10ˢ.39	−3′ 17″.5	19ʰ 55ᵐ 56ˢ.73	+36° 34′ 33″.5	9.555	9.991	Aitken
Oct. 24	15 15 54	2	10	10	+12.99	−3 42.5	19 58 04.55	+36 18 10.8	9.308	9.596	Neubauer
Oct. 28	17 37 58	3	10	10	− 7.86	+ 08.5	20 07 27.11	+35 07 09.2	9.684	0.341	Shane
Oct. 28	18 02 32	4	10	10	− 5.46	− 10.0	20 07 29.51	+35 06 50.7	9.710	0.410	Aitken
Nov. 11	18 15 00	5	10	10	− 9.30	−1 23.1	20 41 08.88	+31 12 49.3	9.716	0.537	Pearce
Nov. 11	19 22 00	6	10	10	− 2.44	−2 11.2	20 41 15.74	+31 12 01.2	9.737	0.652	Pearce
Nov. 17	17 10 45	7	10	10	+ 6.15	−2 42.4	20 55 46.66	+29 25 54.2	9.660	0.451	Pearce
1923											
Jan. 6	14 55 46	9	10	10	− 8.04	−2 04.7	22 57 50.08	+19 08 00.1	9.549	0.533	Pearce
Jan. 6	17 32 39	10	10	10	+ 3.03	+ 56.3	22 58 05.38	+19 07 09.6	9.693	0.684	Pearce
Jan. 6	17 59 17	11	10	10	+ 4.74	+ 53.1	22 58 07.04	19 07 06.1	9.694	0.698	Jacobsen
Jan. 13	17 30 15	12	10	10	−10.90	+ 41.1	23 13 52.89	18 17 40.5	9.690	0.690	Jacobsen
*Feb. 17	15 20 40	13	10	8	−11.02	−2 20.7	0 26 58.10	15 58 32.8	9.656	0.644	Jacobsen

* This observation was made with the 12-inch refractor

MEAN PLACES OF COMPARISON STARS FOR 1922.0

Star	α	Red. to App. place	δ	Red. to App. place	Authority
1	19ʰ 55ᵐ 44ˢ.52	+1ˢ.82	+36° 37′ 18″.4	+32″.6	Potsdam Photo. plate 920, Nr. 442
2	19 57 49.74	+1.82	+36 21 20.7	+32.6	A. G. Lund 8927
3	20 07 33.14	+1.83	+35 06 28.3	+32.4	Potsdam Photo. plate 615, Nr. 245
4	20 07 33.14	+1.83	+35 06 28.3	+32.4	Potsdam Photo plate 615, Nr. 245
5	20 41 16.24	+1.94	+31 13 40.1	+32.3	A. G. Leiden 8445
6	20 41 16.24	+1.94	+31 13 40.1	+32.3	A. G. Leiden 8445
7	20 55 38.53	+1.98	+29 28 04.7	+31.9	Micrometer Comparison with (8)
8	20 55 44.65	+1.98	+29 30 59.9	+31.9	A. G. Cambridge 11980

MEAN PLACES OF COMPARISON STARS FOR 1923.0

Star	α	Red. to App. place	δ	Red. to App. place	Authority
9	22^{h} 57^{m} $58^{s}.65$	$-0^{s}.53$	$+19^{\circ}$ $09'$ $58''.7$	$+6''.1$	A. G. Berlin A 9412
10	22 58 02.88	-0.53	$+19$ 06 07.2	$+6.1$	A. G. Berlin A 9413
11	22 58 02.88	-0.53	$+19$ 06 07.2	$+6.1$	A. G. Berlin A 9413
12	23 14 04.29	-0.51	$+18$ 16 54.8	$+4.5$	A. G. Berlin A 9516
13	0 27 09.65	-0.52	$+16$ 00 55.7	-2.2	A. G. Berlin A 131

With the exception indicated above, all the observations were made with the 36-inch refractor, the measures of $\Delta\alpha$ and $\Delta\delta$ in every case being obtained directly with the micrometer. Corrections for differential refraction have been applied whenever they were appreciable. Acknowledgement is made to Mr. T. S. Jacobsen for reducing his observations and duplicating part of the computation.

J. A. PEARCE.

Lick Observatory,
May 24, 1923.

Issued August 8, 1923.

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ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 348

MEASURES OF A SELECTED LIST OF DOUBLE STARS

MADE IN THE YEARS 1913–1922, WITH NEW ORBITS OF EIGHT SYSTEMS

My time at the telescope during the past ten years has been given almost exclusively, first, to the completion of the survey of the sky, initiated in 1899 to collect data for a statistical study of the number and distribution of the closer double stars, and secondly, to the remeasurement at a second epoch of all new pairs discovered in the course of that survey. A certain number of the closer and more difficult pairs discovered by other observers was also kept under observation; and during the last two or three years, as my larger program approached completion, some of the closer pairs discovered by Professor Hussey were placed upon my observing list as well as a few miscellaneous wider pairs for which recent measures were lacking. Adding a few pairs which were thought to be new when first measured, 326 pairs (in addition to the A stars) have been measured in the years 1913-1922, inclusive, of which approximately one-half are pairs in comparatively rapid orbital motion. The 1368 observations of these stars are published in the present paper.

Orbits are available for 69 of these pairs and the residuals obtained by comparing the observed with the computed places are given in connection with the measures. They will afford the means of estimating the accuracy of the observations as well as of the orbits. In eight cases the measures here printed have been utilized, in connection with the earlier ones, to compute new orbits. The details of the computations will be found following the measures of the various systems, but for convenient reference the orbit elements are tabulated here.

Table of New Orbits of Double Stars

Star	P (years)	T	e	a	ω	i	☊	n	Page
Σ 412	270.	1917.3	0.555	0″49	348°	40°6	97°0	− 1°3333	66
β 1185	28.9	1917.8	0.20	0.25	301.6	75.65	24.3	−12.4566	70
β 552	86.0	1886.35	0.51	0.56	309.6	39.35	145.8	+ 4.1860	71
β 794	63.1	1911.00	0.41	0.34	126.9	34.5	149.7	+ 5.7052	77
β 1270	38.1	1911.58	0.41	0.21	24.4	20.5	126.1	+ 9.4488	79
Hu 1176	15.5	1919.9	0.14	0.16	308.4	56.0	90.8	−23.2258	83
OΣ 341	19.75	1917.85	0.96	0.30	149.0	77.5	98.0	+18.2275	85
β 1266	40.	1909.8	0.33	0.22	133.	48.	46.	− 9.0000	97

There are no other orbits for β1185, Hu 1176, or OΣ341; Jackson has orbits for Σ412 and β552, computed about the same time as my own; the orbits of β794, β1270, and β1266 are revisions of those given in Volume XII of the *Publications of the Lick Observatory*.

The methods of measurement have been fully described in the volume just named and need not be taken up here. The arrangement of the results, also, is the same as in that volume, except that the column giving the telescope and the power of the eye-piece has been omitted since all of these measures have been made with the 36-inch refractor. It is to be understood that for pairs closer than 0″5 powers of 1000 or 1500 and, occasionally for the very closest pairs, of 3000 have been employed. For wider pairs, and particularly for those wider than 2″0, the 520-power eye-piece has generally been used. The blackfaced figures at the left of the star's name give its number in Burnham's *General Catalogue* of *Double Stars* or in Jonckheere's *Catalogue* (*Mem. R. A. 61*, 1917). I have added the spectral class for all pairs contained within the *Henry Draper Catalogue*, taking the magnitudes of the components of these pairs, unless otherwise specially noted, from the data in that catalogue and my observations of the difference of magnitude. For pairs not in this catalogue, no spectral class is recorded and the magnitudes are based upon the value in the B.D. and the observed difference of magnitude. I am indebted to Dr. Harlow Shapley and Miss Annie J. Cannon, of the Harvard College Observatory for their kindness in supplying data for stars in the last five hours of right ascension in advance of the publication of the volumes of the *Henry Draper Catalogue* for these hours.

Robert G. Aitken.

January, 1923.

Issued, November 23, 1923.

J.C. 3 Hu 1201

R.A. $0^h 00^m 21^s$ Decl. +33° 33′

8.1 9.5 F8

1921.852	292°.3	0″.13	$22^h.5$	4
1922.843	291.4	0.12	2.0	3
1922.35	291°.8	0″.12	2n.	

Hussey's position is 1905.21 312°.5 0″.16 2n

12755 Σ 3062

R.A. $0^h 01^m 02^s$ Decl. +57° 53′

6.5 7.5 G5

1914.652	8°.1	1″.50	$21^h.8$	3
.679	8.3	1.57	20.8	2
1920.607	19.3	1.43	21.7	2
.667	20.8	1.26	2.5	3

Comparison with Doberck's ephemeris (*A.N.* **173**, 257, 1906) gives:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.67	8°.2	1″.54	+1°.0	0″.00
1920.64	20.0	1.34	+1.2	−0.12

3 β 1155

R.A. $0^h 01^m 42^s$ Decl. +3° 54′

9.2 10.2 F0

1918.608	84°.0	0″.42	$23^h.3$	3

21 Σ 2

R.A. $0^h 03^m 48^s$ Decl. +79° 10′

6.8 7.1 A3

1914.649	127°.3	0″.22	1.9	3
.704	127.9	0.24	21.6	3
1920.607	110.0	0.20	22.3	2
.667	110.4	0.17	3.1	3
1921.688	108.8	0.23	23.7	4
.694	106.8	0.24	23.4	3

Comparison with Russell's preliminary orbit (*Pub. A.A.S.* **3**, 328, 1917), gives the following residuals:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.68	127°.6	0″.23	+ 3.0	0″.00
1920.64	110.2	0.19	+11.4	−0.01
1921.69	107.8	0.24	+14.3	+0.04

62 β 1026

R.A. $0^h 06^m 53^s$ Decl. +53° 04′

7.2 8.0 F0

1914.649	22°.3	0″.18	$2^h.2$	2
.653	28.2	0.14	21.6	3
.704	31.0	0.18	21.8	2
1917.688	57°.0	0″.14	$3^h.7$	2
.707	57.4	0.14	2.8	3
1919.766	235.±	0.10±	21.2	3
1920.607	222.7	0.14	22.0	2
.667	244.2	0.13	2.8	2
.670	227.8	0.11	22.2	3
1921.617	217.4	0.10±	22.3	3
.694	223.2	0.10±	23.2	3
1914.67	27°.2	0″.17	3n	
1917.70	57.2	0.14	2n	
1919.77	(235.±)	0.10±	1n	
1920.65	231.6	0.13	3n	
1921.66	220.3	0.10±	2n	

The position angles for the years 1919-1921 are very uncertain and the quadrant is indeterminate, but a plot of the earlier measures, from 1888, indicates that the orientation here given is the correct one. The measured distances on the first two nights in 1920 are probably too large.

74 β 998

R.A. $0^h 08^m 32^s$ Decl. +6° 01′

9.2 9.4 F2

1921.737	112°.4	1″.08	$22^h.0$	2
.751	112.9	1.11	23.8	3
1921.74	112°.6	1″.10	2n	

81 β 486

R.A. $0^h 9^m 21^s$ Decl. −8° 20′

5.4 12.0 Ma

1921.737	4°.8	2″.99	$0^h.0$	2
.751	4.6	2.79	23.6	3
1921.74	4°.7	2″.89	2n	

104 OΣ 4

R.A. $0^h 11^m 30^s$ Decl. +35° 56′

8.1 8.8 G0

1914.652	293°.7	0″.20	$22^h.0$	3
.660	303.9	0.20	22.0	3
.764	298.3	0.21	22.0	3
1920.670	266.4	0.26	22.4	3
.681	266.8	0.28	3.0	3

Comparison with Russell's orbit (*Pub. A.A.S.* **3**, 328, 1917) results in the following residuals:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.69	298°.6	0″.20	−2°.9	−0″.05
1920.68	266.6	0.27	−8.7	−0.06

153 β 1093

R.A. 0^h 15^m 40^s Decl. +10° 25′

7.0 7.8 A0

1917.989	83°6	0″34	1^{h}4	
1921.644	83.2	0.49	23.7	
.652	87.0	0.50	23.3	
.729	82.9	0.43	22.4	
1921.68	84°4	0″47	3n	

Very slow direct angular motion. The distance measure in 1917 was marked as "poor" because of bad seeing.

180 Hu 506

R.A. 0^h 18^m 52^s Decl. +51° 28′

5.6 7.2 B3

1921.839	234°8	0″17	22^{h}0	3
.852	230.6	0.17	22.2	4
1921.85	232°7	0″17	2n	

Hussey's discovery position was 1902.71 217°1 0″19.

254 β 1158

R.A. 0^h 25^m 56^s Decl. −10° 38′

9.5 9.5 G0

1921.737	162°0	0″43	0^{h}2	2
.751	162.2	0.42	1.0	3
1921.74	162°1	0″42	2n	

A and BC = H 1981 A = 6.7 A 3

1921.74	88°0	79″44	0^{h}4	2

Slow direct angular motion in the close pair.

298 Secchi 1

R.A. 0^h 29^m 23^s Decl.—5° 6′

7.5 8.0 G0

1917.992	250°4	0″60	0^{h}5	3
1918.002	250.2	0.58	1.1	2
1918.00	250°3	0″59	2n	

Also known as Δ2. Very slow direct angular motion.

314 Ho 212 13 *Ceti*

R.A. 0^h 30^m 06^s Decl.—4° 09′

5.6 6.4 G0

1914.616	256°6	0″29	0^{h}8	3
.632	257.8	0.27	0.8	3
.635	254.7	0.30	0.4	3
1915.676	270.5	0.32	1.8	3
.739	271.7	0.28	1.0	2
1916.708	283.3	0.28	0.9	3
.713	292.2	0.27	1.0	4
1917.715	318.4	0.15	0.7	3
.992	328.6	0.12	0.3	3
1918.002	344.4	0.12	0.8	2
1920.628	245.4	0.25	1.0	2
.640	245.9	0.25	0.5	2
1921.628	259.4	0.27	0.9	3
.644	261.8	0.30	0.5	3
1922.614	276.6	0.24	0.3	2
.633	270.2	0.28	1.1	3
.814	275.0	0.33	0.0	3

A comparison of these measures with positions computed from my orbit (*Lick Obs. Publ.* **12**, 6, 1914) follows:

	θ_0	ρ_0	(O–C)$\Delta\theta$	$\Delta\rho$
1914.63	256°4	0″29	−2°7	−0″01
1915.71	271.1	0.30	−3.8	+0.02
1916.71	287.8	0.28	−6.3	+0.05
1917.71	318.4	0.15	−5.0	−0.03
1918.00	335.6	0.12	+0.9	−0.05
1920.63	245.6	0.25	−0.2	−0.03
1921.64	260.6	0.28	+0.8	−0.02
1922.69	272.9	0.28	−3.7	+0.01

317 OΣ 15

R.A. 0^h 30^m 20^s Decl. +48° 28′

7.3 8.3 Comp.

1914.652	304°5	0″18	22^{h}4	3
.822	304.8	0.15	22.0	3
1921.655	301.9	0.17	22.9	3
.839	304.0	0.15	22.2	3
1914.74	304°6	0″16	2n	
1921.75	303.0	0.16	2n	

The character of the motion is still quite uncertain because there are very few measures. Miss Cannon (H.D. 3210-11) notes that the spectrum is composite and very peculiar. "Several strong lines which appear to belong to a spectrum of Class K are superposed on one of Class A."

324 β 1096

R.A. 0^h 30^m 57^s Decl. +57° 58′

9.5 9.5 ——

1921.800	Uncertain.		21^{h}4	2
.830	Distance	<0″15	21.9	3

On the second night elongation in 253°∓ was suspected.

330 β 1097

R.A. 0^h 31^m 37^s Decl. +57° 28′

8.0 8.3 B9

1921.800	249°8	0″46	21^{h}2	2
.830	247.6	0.42	21.7	3
1921.82	248°7	0″44	2n	

335 β 395

R.A. 0^h 32^m 13^s Decl. −25° 19′

6.4 6.4 K0

1914.635	112°0	0″70	0^{h}6	3
.701	110.7	0.76	0.5	3
1916.708	115.2	0.63	0.7	4
.713	116.3	0.62	0.8	4
1917.754	119.5	0.60	1.6	2
.989	115.5	0.52	0.7	2
1918.564	121.4	0.60	0.4	3
1918.942	123.7	0.54	0.6	3
.953	121.7	0.44	0.3	2
.980	121.4	0.50	0.8	3
1920.850	150.0	0.18	0.6	3
.869	165.7	0.15	1.2	2
1921.570	190.9	0.16	0.4	2
.579	193.5	0.14	0.3	3
.644	189.1	0.18	0.7	3
1922.794	272.2	0.35	0.8	3
.814	268.4	0.28	0.5	3

335—(*Continued*)

Comparison with the positions computed from my orbit (*Lick Obs. Publ.* **12**, 7, 1914) gives the following residuals:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.67	111°.3	0″.73	+1°.0	−0″.02
1916.71	115.8	0.62	∓0.0	−0.04
1917.87	117.5	0.56	−2.0	∓0.00
1918.56	121.4	0.60	−0.8	+0.13
1918.96	122.3	0.49	−1.8	+0.08
1920.86	157.8	0.16	+2.0	±0.00
1921.60	191.2	0.16	+10.6	−0.01
1922.80	270.3	0.32	+1.9	+0.02

There are no other measures for the part of the orbit covered by the observations from 1917 to 1921, inclusive.

359 β 257

R.A. $0^h 34^m 42^s$ Decl. +46° 42′

8.1 9.1 G0

1918.663	239°.7	0″.59	$22^h.1$	3

No change since discovery in 1876.

374 OΣ 18

R.A. $0^h 37^m 14^s$ Decl. +3° 37′

7.6 9.7 F8

1914.701	144°.8	1″.15	$0^h.8$	3
.822	141.9	1.13	22.5	2
1920.954	151.4	1.16	1.5	2
1921.751	152.3	1.20	1.2	3
1914.76	143°.4	1″.14	2n	
1921.35	151.8	1.18	2n	

425 Ho 306

R.A. $0^h 42^m 47^s$ Decl. +25° 00′

9.8 10.1 G5

1921.737	167°.1	1″.29	22.3	2
.789	167.3	1.24	23.3	2
1921.76	167°.2	1″.26	2n	

426 Σ 60 *η Cassiopeiae*

R.A. $0^h 43^m 03^s$ Decl. +57° 17′

3.6 7.9 F8

1914.704	248°.9	6″.63	$21^h.9$	3
.822	250.7	6.61	21.6	3
1914.76	249°.8	6″.62	2n	

Doberck's orbit (*A.N.* **179**, 383, 1909) gives, for this date, 250°.1, 6″.67. According to Adams the spectra of the two components are, respectively, G0, K0.

477 Hu 802

R.A. $0^h 49^m 12^s$ Decl. +48° 52′

8.2 8.6 A0

1921.839	211°.9	0″.35	$22^h.7$	3
.852	213.1	0.29	22.7	3
1921.85	212°.5	0″.32	2n	

482 Σ 73

R.A. $0^h 49^m 37^s$ Decl. +23° 05′

7.1 7.6 K0

1916.960	45°.5	0″.66	$23^h.3$	3
1917.762	43.9	0.71	3.2	3
1921.652	56.6	0.77	23.6	2
.655	55.4	0.66	23.4	2

Bowyer's elements (*Mem. R. A. S.*, **56**, 23, 1906) represent these observations more closely than do those published by Rabe in 1914 or those published by Jackson in 1920. The residuals are:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1917.36	44°.7	0″.68	+1°.8	−0″.15
1921.65	56.0	0.72	+1.1	−0.01

488 β 1028 *γ Cassiopeiae*

R.A. $0^h 50^m 40^s$ Decl. +60° 11′

2.2 11.0 B0p

1921.770	254°.5	1″.97	$22^h.7$	3
.800	251.6	2.19	21.5	2
1921.78	253°.0	2″.08	2n	

489 β 1099

R.A. $0^h 50^m 45^s$ Decl. +59 49′

6.0 6.7 A0

1914.638	344°.3	0″.35	$22^h.9$	2
.704	345.2	0.33	22.4	2
1917.811	350.9	0.28	21.9	3
1921.617	355.6	0.33	22.7	3
.622	358.5	0.33	22.4	2
1914.67	344°.8	0″.34	2n	
1917.81	350.9	0.28	1n	
1921.62	357.0	0.33	2n	

524 Mädler

R.A. $0^h 54^m 53^s$ Decl. +46 47′

7.9 9.1 A2

1921.830	27°.6	0″.94	$23^h.2$	2
.839	27.7	0.91	22.4	2
1921.83	27°.6	0″.92	2n	

Burnham thought the measures to 1906 showed no change, but apparently the angle is slowly diminishing.

527 β 867

R.A. $0^h 54^m 59^s$ Decl. +11° 24′

8.5 9.0 A5

1921.737	163°.6	0″.81	$23^h.4$	2
.751	164.4	0.74	0.0	3
1921.74	164°.0	0″.78	2n	

537 β 1161

R.A. $0^h 57^m 03^s$ Decl. +51 16′

7.2 8.0 B5

1921.770	336°.4	0″.45	23.6	3
.800	337.7	0.44	21.9	3
1921.78	337°.0	0″.44	2n	

541 OΣ 21

R.A. 0h 57m 16s Decl. +46° 50′

6.4 8.4 F0

1914.660	147°±	0″.10±	23h.0	3
1914.821 to 1920.607	Too close to measure			
1921.707	176.2	0.13	23.0	3
.800	178.4	0.13	22.7	3
1921.75	177°.3	0″.13	2n	

The difference in magnitude here recorded is based upon Otto Struve's estimates. In 1921, the quadrant was indeterminate. The companion is placed in the second quadrant to harmonize with my measures in 1904-08. Burnham's statement in the *G.C* that it is difficult to reconcile all the results obtained for this pair still holds true.

572 β 1228

R.A. 1h 00m 33s Decl. +12° 47′

9.5 10.3 ——

1921.737	264°.6	0″.80	23h.6	2
.751	265.2	0.83	0.2	3
1921.74	264°.9	0″.82	2n	

595 A. Clark 13

R.A. 1h 03m 08s Decl. +44° 40′

8.2 8.7 A0

1921.830	255°.7	0″.45	23h.5	2
.839	257.5	0.38	23.0	2
1921.83	256°.6	0″.42	2n	

600 OΣ 515 = φ *Andromedae*

R.A. 1h 03m 42s Decl. +46° 43′

4.5 6.1 B8

1914.638	205°.7	0″.33	23h.2	2
.657	207.9	0.25	23.3	2
.660	209.2	0.35	22.7	3
1920.607	200.3	0.27±	23.2	2
1921.600	194.8	0.33	23.0	3
.617	195.8	0.35	23.2	3

1914.65	207°.6	0″.31	3n
1920.61	200.3	0.27±	1n
1921.61	195.3	0.34	2n

Burnham's diagram (*G.C.* II, 291) is in error, the positions for 1894 to 1899 being plotted on a scale twice that of the others. The observed motion since 1851 can be fairly well represented by a straight line, but the velocity along that line has varied, and the pair is certainly a long period binary.

637 β 258

R.A. 1h 06m 48s Dec. +61° 41′

6.4 8.6 B9

1921.770	261°.8	1″.00	23h.2	3
.800	260.1	1.00	21.7	3
1921.78	261°.0	1″.00	2n	

648 β 1029 ζ *Piscium*

R.A. 1h 08m 32s Decl. +7° 03′

6.5 11.0 F8

Burnham's faint companion to the star B of the wide Struve pair could not be seen with the 36-inch on several nights in the period 1914 to 1922. The seeing was good enough to make it certain that this faint star was either much closer to its primary or much fainter than when I measured its position in 1896.

670 Hu 520

R.A. 1h 11m 48s Decl. +49° 14′

8.6 8.8 A2

1921.830	165°.4	0″.21	23h.8	2
.839	165.0	0.22	23.4	2
1921.83	165°.2	0″.22	2n	

672 Σ 102

R.A. 1h 11m 51s Decl. +48° 29′

7.2 8.2 A0

1921.830	298°.4	0″.49	23h.6	2
.839	298.6	0.53	23.2	2
1921.83	298°.5	0″.51	2n	

689 Hu 521

R.A. 1h 13m 24s Decl. +48° 26′

9.6 9.6 A0

1921.839	97°.1	0″.35	23h.6	2
.852	97.7	0.28	22.9	3
1921.85	97°.4	0″.32	2n	

702 Hu 523

R.A. 1h 14m 38s Decl. +51° 04′

7.2 10.5 B9

1921.852	86°.6	0″.35	23h.0	4
1922.978	86.4	0.30	4.6	3
1922.22	86°.5	0″.32	2n	

The discovery position was 1902.62, 98°.7, 0″.38 4n Hussey.

743 β 1163

R.A. 1h 19m 19s Decl. −7° 26′

6.6 6.8 F0

1914.632	218°.6	0″.36	1h.1	2
.690	213.6	0.32	1.9	3
1915.676	214.4	0.34	2.2	3
1919.013	211.5	0.30	1.9	2
1921.655	204.4	0.25	0.8	3
.666	206.7	0.27	1.0	2
.710	206.6	0.27	0.6	3

1914.76	216°.1	0″.34	2n
1915.68	214.4	0.34	1n
1919.01	211.5	0.30	1n
1921.68	205.9	0.26	3n

The difference of magnitude is that assigned by Burnham. The two components appeared to me of equal brightness except on the last night when the north star seemed the fainter one. It is possible that the quadrant has changed since 1903 but the measures are too few and too discordant to decide definitely.

746 Ho 310

R.A. 1h 19m 59s Decl. +28° 01′

9.6 9.8 ——

1921.737	356°8	1″49	22h5	2
.789	355.8	1.51	23.5	2
1921.76	356°3	1″50	2n	

768 β 399

R.A. 1h 22m 47s Decl. − 11° 25′

6.3 10.0 K0

1921.737	306°5	1″49	0h5	2

830 Σ 138

R.A. 1h 30m 49s Decl. +7° 08′

7.6 7.6 F8

1917.023	38°3	1″31	2h9	2

The angular motion since 1830 does not exceed 20°.

846 Hu 529

R.A. 1h 33m 20s Decl. +49° 59′

9.4 9.9 A0

1921.839	85°9	0″22	23h9	2
.852	83.4	0.27	23.2	3
1921.85	84°6	0″24	2n	

848 β 508

R.A. 1h 33m 34s Decl. +26° 26′

9.7 10.4 F8

1921.737	64°0	0″70	22h8	2
.792	63.0	0.59	23.7	2
1921.76	63°5	0″64	2n	

Burnham, on a single night in 1877, found 71°1, 1″02, but the later measures (from 1900 on) show no change in either coordinate.

J.C. 252 Hu 1210

R.A. 1h 36m 20s Decl. +49° 30′

9.7 9.7 ——

1921.852	57°2	0″19	23h4	3
1922.978	59.5	0.22	4.8	3
1922.42	58°4	0″20	2n	

915 Hu 532

R.A. 1h 40m 15s Decl. +49° 54′

9.2 10.2 A0

1921.852	131°9	0″28	23h6	3
1922.978	133.3	0.25	5.0	3
1922.42	132°6	0″26	2n	

917 Hu 804

R.A. 1h 40m 28s Decl. +33° 13′

8.6 10.0 F2

1921.628	361°7	0″30	23h9	3
.707	358.8	0.31	23.9	3
1921.67	360°2	0″30	2n	

The only published measure is Hussey's which is 1903.62, 337°6, 0″27.

956 β 1016

R.A. 1h 44m 00s Decl. +32° 34′

9.5 9.7 ——

1921.737	209°9	0″71	23h1	2
.789	209.0	0.61	23.9	2
1921.76	209°4	0″66	2n	

These measures do not confirm the change in angle indicated by Leavenworth's measures in 1916 (*A.J.* 708).

J.C. 278 Hu 1213

R.A. 1h 46m 36s Decl. +12° 56′

9.5 9.7 A3

1921.628	136°0	0″20	0h2	3
.710	133.7	0.19	1.0	3
1921.67	134°8	0″20	2n	

Hussey's measures in 1904-5, the only ones published, are discordant, but comparison with them indicates slow retrograde motion.

1002 Σ 183

R.A. 1h 49m 26s Decl. +28 19′

7.7 8.4 F2

1917.937	353°3	0″46	23h3	2
1921.732	350.7	0.42	23.9	2
.800	350.5	0.45	23.4	3
1921.77	350°6	0″44	2n	

A, B and C—9.4

1917.937	165°0	5″44	23.6	2

1036 β 513 48 *Cassiopeiae*

R.A. 1h 53m 44s Decl. +70° 25′

4.7 7.2 A3

1914.638	171°5	0″50	23h5	3
.657	179.0	0.48	23.6	2
.660	171.6	0.54	23.6	3
1915.618	178.2	0.58	0.4	3
1916.127	183.5	0.68	4.5	3
1916.951	182.4	0.63	23.6	3
1917.776	188.8	0.76	3.7	3
.956	186.2	0.60	0.2	3
.967	188.7	0.63	0.1	2
1921.688	202.0	0.67	0.0	4
.694	202.6	0.71	23.6	3

Comparison with positions computed from Rabe's elements (letter) gives the following residuals:

	θ_0	ρ_0	(O–C)$\Delta\theta$	$\Delta\rho$
1914.65	174°0	0″51	−2°5	−0″01
1915.87	180.8	0.63	−2.2	+0.07
1916.95	182.4	0.63	−5.6	+0.02
1917.90	187.9	0.66	−3.8	+0.01
1921.69	202.3	0.69	−0.8	−0.10

1058 Hu 806

R.A. $1^h 56^m 45^s$ Decl. +48° 08′

7.9 13.2 G0

1921.839	153°7	1″64	0^h1	2
.852	153.0	1.60	23.7	3
1921.85	153.4	1″62	2n	

A and C—14.2

1921.839	139°2	8″54	0^h2	2
.852	139.7	8.85	23.8	3
1921.85	139°4	8″70	2n	

On a single night in 1904 I measured a star 14.5 magnitude 11″93 from A in 127°8. I could see no star in that position in 1921. If it is identical with C, above, the earlier measure is probably in error. Hussey measured the closer pair only.

1070 OΣ 38 γ *Andromedae*

R.A. $1^h 57^m 56^s$ Decl. +41° 51′

5.4 6.5 A0

1916.960	108°3	0″51	23^h6	3
1917.956	105.0	0.52	23.5	3
.967	109.4	0.52	23.8	2
1921.548	107.1	0.59	23.5	3
.559	105.7	0.57	23.9	3

A and BC = Σ 205

3.3 5.1

1916.960	62°9	10″06	23^h8	3
1917.956	62.0	9.91	23.7	3
.967	62.6	9.85	23.9	2
1917.96	62°3	9″88	2n	

Professor Hussey's orbit (*Lick Obs. Publ.* **5**, 45, 1901) represents my measures as follows:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1916.96	108.3	0″51	−0°9	−0″09
1917.96	107.2	0.52	−1.6	−0.08
1921.55	106.4	0.58	−1.4	±0.00

1074 Σ 208

R.A. $1^h 57^m 59^s$ Decl. +25° 27′

5.7 7.9 F5

1915.829	112°8	0″38	0^h5	2
1916.951	117.1	0.35	0.0	2
1920.607	140.1	0.32±	0.2	2
1921.614	147.7	0.39	23.8	2
.617	146.9	0.35	23.7	3
1921.62	147.3	0.37	2n	

1144 Σ 228

R.A. $2^h 07^m 38^s$ Decl. +47° 01′

6.4 7.3 F0

1916.683	112°0	0″67	0^h6	3
.960	112.0	0.60	0.0	3
1917.592	116.3	0.60	0.4	2
1920.607	118.8	0.60±	23.9	2
1921.614	125.8	0.56	0.0	2
.617	124.4	0.56	23.9	3

The latest orbit for this pair is Jackson's (*M.N.* **80**, 546, 1920). Comparison with it gives the following residuals:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1916.82	112°0	0″64	−0°3	−0″14
1917.59	116.3	0.60	+2.9	−0.17
1920.61	118.8	0.60±	±0.0	−0.16
1921.62	125.1	0.56	+3.4	−0.19

Jackson remarks that "recent measures of distance appear to be too small in comparison with the earlier ones." His distance residuals from 1903 on are all negative.

1164 Σ 234

R.A. $2^h 10^m 01^s$ Decl. +60° 53′

8.5 9.4 G0

1921.622	287°4	0″29	23^h4	2
.636	287.5	0.26	0.4	2
.852	282.9	0.29	0.5	3
1921.70	285°9	0″28	3n	
1923.024	276.0	0.24	3.6	2

The small star is now certainly in the fourth quadrant, and the pair is not a difficult one to measure under good conditions. In 1916.95 I could not measure it, but suspected elongation in a north-south direction. Struve's position, in 1831, was 239°2 0″84, and the few later measures given in the *G.C.* indicate slow retrograde angular motion. This pair should be observed regularly during the next few years.

1212 Σ 248

R.A. $2^h 14^m 47^s$ Decl. +42° 20′

9.4 9.4 ——

1921.789	143°4	1″12	0^h6	2
.800	143.8	1.19	23.1	2
1921.79	143°6	1″16	2n	

1235 Σ 257

R.A. $2^h 18^m 10^s$ Decl. +61° 05′

7.8 8.1 B8

1914.638	257°5	0″25	0^h0	2
.660	258.8	0.20	23.8	3
1916.951	265.7	0.21	23.8	3
1917.967	267.6	0.30	0.4	3
1921.622	279.4	0.24	23.6	2
.636	282.2	0.23	0.6	2
1923.024	286.3	0.28	3.8	2

1914.65	258°2	0″22	2n
1916.95	265.7	0.21	1n
1917.97	267.6	0.30	1n
1921.63	280.8	0.24	2n
1923.02	286.3	0.28	1n

1299 OΣ 42

R.A. $2^h 26^m 27^s$ Decl. +51° 52′

7.0 7.5 A2

1914.660	Too close to measure		0^h0	3
1921.688	31°5	0″10	0.9	4
.694	37.5	0.13	0.0	3
1921.69	34°5	0″12	2n	

The difference in magnitude is taken from Otto Struve's observations.

12902 Hu 1041

R.A. 2h 29m 33s Decl. +64° 54′

8.7 9.2 B8

1921.830	67°1	0″24	0h2	3
.839	67.1	0.28	1.0	2
1921.83	67°1	0″26	2n	

J.C. 400 Hu 1216

R.A. 2h 32m 18s Decl. −11° 38′

8.6 10.1 G0

1921.644	282°4	0″58	1h4	2
.655	279.7	0.57	1.8	3
1921.65	281°0	0″58	2n	

Decided change. Hussey, on one night in 1900.90 found 249°3, 0″31, and my measures in 1906.87 (2n) gave 261°6, 0″48.

1360 Hu 538

R.A. 2h 34m 45s Decl. +52° 28′

9.6 10.1 ——

1921.839	309°2	0″33	0h7	2
.852	310.0	0.27	0.7	3
1921.85	309°6	0″30	2n	

1370 Hu 539

R.A. 2h 35m 33s Decl. +48° 59′

9.1 9.4 F5

1921.830	63°4	0″31	0h4	2
.839	65.3	0.36	0.4	2
1921.83	64°4	0″34	2n	

Hussey's measure is 1902°00, 80°7, 0″30, 3n.

1465 Ho 218

R.A. 2h 46m 09s Decl. +2° 39′

8.7 8.7 F2

1921.691	22°±	0″10±	2h3	3

Elongation in 45°± was suspected on the date 1918.671. On several later nights in the same year it was recorded as too close to measure. In 1921 the elongation seemed quite definite.

1471 β 524 20 *Persei*

R.A. 2h 47m 24s Decl. +37° 56′

5.6 6.7 F0

1914.660	323°3	0″20	0h3	3
.701	319.8	0.21	1.0	3
1917.674	301.2	0.20	1.1	3
1918.660	294.6	0.19	1.2	3
1920.607	282.3	0.15±	0.8	2
1921.600	276.2	0.20	0.7	3
.636	282.0	0.19	1.0	2
.663	282.8	0.16	0.6	3
1922.978	273.6	0.12	5.2	3
23.016	276.4	0.22	5.7	2

	θ_0	ρ_0	(O-C)$\Delta\theta$	$\Delta\rho$
1914.68	321°6	0″20	− 6°4	−0″04
1917.67	301.2	0.20	−17.0	−0.03
1918.66	294.6	0.19	−20.5	−0.03
1920.61	282.3	0.15±	−24.3	−0.05
1921.63	280.3	0.18	−21.3	−0.01
1923.00	275.0	0.17	−18.1	+0.02

The comparison indicated is with positions computed from my orbit (*Lick Obs. Publ.* **12**, 20, 1914) and shows that the orbit requires revision. The apparent motion of the companion during the next few years will be extremely rapid and systematic measures in these years will afford data for a much better orbit than can be computed at present.

1501 β 1173

R.A. 2h 52m 47s Decl. +23° 44′

8.3 8.4 K0

1914.660	351°9	0″16	0h8	3
.676	344.7	0.15	1.2	2
.701	353.3	0.15	1.3	3
1921.688	13.4	0.17	1.2	3
.694	354.8	0.16	0.6	3
.710	5.2	0.15	1.3	3
1914.68	350°0	0″15	3n	
1921.70	4.5	0.16	3n	

AB and C 7.6 13.0

1914.660	280°8	4″62	0h9	3
1921.694	281.7	4.43	0.8	3

The close pair shows slow direct angular motion, the change amounting to about 30° since Burnham's discovery in 1890. It is a very difficult pair to measure.

1508 β 525

R.A. 2h 53m 09s Decl. +21° 13′

7.4 7.4 A3

1914.660	169°8	0″25	0h6	3
.676	163.0	0.26	1.0	2
.701	163.1	0.24	1.6	3
1917.745	173.2	0.25	1.8	3
.945	176.4	0.21	1.5	2
1921.600	183.8	0.25	0.9	2
.614	183.4	0.21	1.8	3
1914.68	165°3	0″25	3n	
1917.84	174.8	0.23	2n	
1921.61	183.6	0.23	2n	

In 1921 the northern star appeared to be the fainter of the two, but I have given the quadrant as above for comparison with the earlier measures. The total angular motion since discovery in 1877 is about 80°.

1516 Ho 13

R.A. 2h 53m 56s Decl. +26° 54′

8.8 12.2 F5

1921.789	162°1	2″44	0h9	2
.800	163.9	2.41	23.7	2
1921.79	163°0	2″42	2n	

1567 β 527

R.A. $3^h\ 01^m\ 20^s$ Decl. −13° 49′

8.2 8.7 F5

1916.946	79°9	0″92	3^h4	2

1591 Ho 500

R.A. $3^h\ 05^m\ 33^s$ Decl. +35° 43′

9.3 9.3 ——

1921.789	40°0	0″62	1^h6	2
.800	38.3	0.66	0.3	2
1921.79	39°2	0″64	2n	

1617 β 530

R.A. $3^h\ 08^m\ 28^s$ Decl. +22° 35′

9.7 10.4 ——

1921.789	13°2	1″71	1^h1	2
.800	14.0	1.67	23.9	2
1921.79	13°6	1″69	2n	

A faint pair 49″ north following a 7th magnitude star. The magnitudes are adopted from Burnham.

1616 Hu 544

R.A. $3^h\ 08^m\ 39^s$ Decl. +50° 35′

6.8 8.8 A0

1921.830	96°3	0″64	0^h7	2
.839	95.0	0.73	1.2	2
1921.83	95°6	0″68	2n	

1619 Ho 502

R.A. $3^h\ 08^m\ 42^s$ Decl. +35° 21′

9.0 9.5 A2

1921.789	17°2	0″66	1^h4	2
.800	16.8	0.70	0.1	3
1921.79	17°0	0″68	2n	

1650 A. Clark 2 95 *Ceti*

R.A. $3^h\ 13^m\ 15^s$ Decl. −1° 18′

5.9 9.0 G5

1914.632	193°1	0″50	2^h0	3
.635	196.7	0.51	0.9	3
1921.688	213.0	0.47	2.4	3
.691	208.1	0.56	2.6	3
1914.63	194°9	0″50	2n	
1921.69	210.6	0.52	2n	

It is not yet possible to harmonize the positive and negative results obtained in the observations of this pair since its discovery in 1853.

1657 β 1177

R.A. $3^h\ 13^m\ 47^s$ Decl. −1° 23′

10.6 10.6 G5

1914.632	353°2	0″27	2^h2	3
.635	354.1	0.30	1.1	3
1920.678	341.7	0.32	3.6	2 –
1921.688	334.8	0.26	2.6	3
.691	332.4	0.26	2.8	3
1914.63	353°6	0″28	2n	
1920.68	341.7	0.32	1n	
1921.69	333.6	0.26	2n	

The measure in 1920 deserves little weight because of the poor seeing.

1761 Σ 412 7 *Tauri*

R.A. $3^h\ 28^m\ 31^s$ Decl. +24° 08′

6.6 6.7 A2

1914.676	117°8	0″19	1^h6	2
.701	119.5	0.18	1.8	3
1915.794	110.4	0.17	1.6	4
1917.745	103.3	0.24	2.1	3
.967	102.6	0.22	1.1	2
1919.698	96.8	0.24	1.2	3
1920.754	92.3	0.22±	2.4	3
1921.688	88.6	0.22	1.5	3
.694	89.1	0.26	1.6	3

THE ORBIT OF Σ 412

Discovered by Struve in 1830 when the two components, of nearly equal brightness, were separated by 0″7, this binary has been observed regularly and the measures now extend over 181° of the apparent ellipse. Unfortunately, the early measures do not cover the maximum separation of the components and any orbit now computed must, to a certain degree, be dependent upon assumptions as to the value of that maximum. Herschel did not see the close pair when he listed the distant companion in 1781, and it seems legitimate to infer that the angular separation was then little if any greater than at the time of Struve's discovery. On this assumption, I computed the following orbit, by graphical methods, in 1919. Some months later the March, 1920, number of the *Monthly Notices, R.A.S.*, reached me, containing Mr. J. Jackson's paper, "The Orbits of 20 Double Stars." One of these stars was Σ 412. I print his set of elements beside my own for comparison. This will show the provisional nature of both orbits. The two orbits give almost identical values for the hypothetical parallax, 0″01, if the combined mass is taken to be 1.7 times that of the Sun. The corresponding absolute magnitudes of the components are +1.6, +1.7.

ELEMENTS

	Aitken	Jackson
P	270.4y	216.94y
T	1917.3	1919.37
e	0.555	0.547
a	0″49	0″407
ω	348°	350°0
i	40.6	37.0
Ω	97.0	106.5
n	−1.333	−1.6597

EPHEMERIS (Aitken)

	θ	ρ
1923.3	81°3	0″23
1925.3	73.4	0.23
1927.3	65.6	0.23
1929.3	58.0	0.23
1931.3	50.6	0.24
1933.3	43.4	0.24
1935.3	46.5	0.25

1761—(*Continued*)

Observations					(O–C)	
					Δθ	Δρ
1830.38	269°.9	0″.69	5n	Σ	+1°.7	+0″.01
1833.21	265.0	0.7	—	Smy.	−1.9	+0.03
1836.90	264.9	0.59	2	Σ	−0.4	−0.07
1839.80	261.1	0.34	1	Challis	−2.8	−0.31
1841.96	263.4	0.60	1	Da	+0.6	−0.04
1842.04	262.9	0.74	3	OΣ	+0.1	+0.10
1842.56	265.4	0.56	5	Mäd.	+2.9	−0.08
1843.12	265.1	0.41	1	Glaisher	+2.8	−0.22
1843.66	261.5	0.48	2	Mäd.	−0.5	−0.15
1846.91	254.6	0.4	1	Da	−5.6	−0.21
1846.99	256.4	0.4	2	Mäd.	−3.8	−0.21
1850.18	264.1	0.64	1	OΣ	+5.6	+0.04
1851.00	257.2	0.42	11	Mäd.	−0.8	−0.17
1854.58	253.9	0.40	5	Mäd.	−1.9	−0.17
1855.99	257.8	0.39	12	Sec.	+2.9	−0.17
1856.62	256.0	0.35	2	Mäd.	+1.5	−0.21
1856.72	255.8	0.42	3	Sec.	+1.4	−0.14
1859.13	252.4	0.5	4	Mäd.	−0.4	−0.04
1863.56	251.9	——	5,0	Δ	+2.3	——
1864.93	240.8	0.55	1	Knott	−7.7	+0.05
1867.16	243.4	——	2	Δ	−3.2	——
1873.31	240.3	0.40	2	W. & G.	−0.5	−0.04
1874.82	231.1	0.48	1	Δ	−8.2	+0.05
1878.57	233.9	0.47	7	Sp.	−0.9	+0.07
1882.60	229.6	0.32	7	Eng.	+0.6	−0.04
1884.09	224.9	0.40	2	Perrot.	−2.0	+0.05
1887.09	215.6	0.28	8	Sp	−5.7	−0.04
1888.07	203.5	0.24	7	Sp	−16.0	−0.08
1888.63	214.1	0.44	5	HΣ	−3.3	+0.13
1889.02	210.0	0.30	7	Sp	−6.8	−0.01
1889.06	212.2	0.25	2	Hl	−4.5	−0.06
1889.64	216.4	0.30	4	β	+0.3	±0.00
1890.10	211.6	0.29	7	Sp	−2.4	−0.01
1891.05	203.1	0.26	6	Sp	−9.5	−0.03
1893.12	200.4	0.26	4	Sp	−8.2	−0.02
1894.44	202.2	0.35	5	HΣ	−1.8	+0.08
1894.65	202.2	0.23	2	Sp	−1.2	−0.04
1896.09	194.4	0.24	12	p	−4.7	−0.01
1896.6	199.5	0.34	8	Gr[1]	+2.1	+0.09
1897.05	190.9	0.20	1	Sp	−4.4	−0.05
1897.99	192.9	0.23	1	Hu	+0.2	−0.01
1899.75	185.9	0.23	4	A	−0.4	±0.00
1901.5	189.5	0.23	11	Gr[1]	+10.1	+0.01
1902.54	179.6	0.22	2	Com	+4.7	±0.00
1903.18	193.2	0.22	2	Com	+23.2	±0.00
1903.98	170.±	——	1	Van B.	+2.±	——
1904.84	165.8	0.16	1	β	+1.2	−0.05
1907.98	152.9	0.28	2–1	Van B	+18.4	+0.08
1908.77	147.0	0.17	2	β	+1.1	−0.03
1910.0	147.6	0.22	4	Gr[1]	+7.9	+0.02
1912.67	127.7	0.17	2	A	+0.7	−0.04
1913.8	131.1	0.21	7	Gr[1]	+9.1	±0.00
1914.69	018.6	0.18	2	A	+0.4	−0.03
1915.79	110.4	0.17	1	A	−2.4	−0.04
1917.86	103.0	0.23	2	A	−2.4	+0.01
1919.66	95.0	0.24	1	Lu	−1.3	+0.02
1919.70	96.8	0.24	1	A	+0.8	+0.02
1920.75	92.3	0.22	1	A	+1.0	∓0.00
1921.14	92.7	0.19	1	Gr	+2.6	−0.03
1921.69	88.8	0. 4	2	A	+1.1	+0.02

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[1] The Greenwich measures are grouped here as given by Jackson in the recent *Greenwich Catalogue of Double Stars*.

12945 Hu 1062

R.A. $3^h 31^m 17^s$ Decl. +63° 33′

9.0 9.5 ——

1921.852	252°.9	0″.12	$1^h.1$	3
.932	251.±	0.12±	1.8	3
1921.89	252°.±	0″.12±	2n	

This is the companion star in the wide double OΣ²36. I think the measured elongation is real, but the pair is now very close. Hussey, in 1905.00, found 234°.5, 0″.19. I have adopted his difference of magnitude.

1795 β 308

R.A. $3^h 33^m 02^s$ Decl. −7° 58′

8.9 9.9 F0

1915.845	327°.6	1″.62	$4^h.4$	2

1838 Barnard 3

R.A. $3^h 38^m 18^s$ Decl. +23° 47′

10.0 10.5 ——

1920.678	146°.6	1″.61	$1^h.5$	3
.746	144.4	1.53	2.3	2
1920.71	145°.5	1″.57	2n	

1849 OΣ 62

R.A. $3^h 39^m 55^s$ Decl. +64° 26′

9.2 9.4 F5

1921.839	151°.0	0″.32	$1^h.7$	2

1856 β 536

R.A. $3^h 40^m 19^s$ Decl. +23° 53′

8.4 9.4 K2

1914.676	227°.8	0″.20	$2^h.0$	2
.701	228.1	0.18	2.0	3
1915.744	221.6	0.15	1.8	4
1917.967	220.8	0.22	1.4	2
1919.698	209.8	0.24	1.0	2
1920.628	214.0	0.20	1.3	2
.678	212.2	0.27	1.2	2
.746	211.2	0.18	1.5	2
1921.688	211.4	0.25	1.8	3
.694	209.7	0.28	1.8	3

1914.69	228°.0	0″.19	2n
1915.74	221.6	0.15	1n
1917.97	220.8	0.22	1n
1919.70	209.8	0.24	1n
1920.68	212.5	0.22	3n
1921.69	210.6	0.26	2n

1863 Hu 546

R.A. $3^h 40^m 54^s$ Decl. +51° 44′

9.0 9.3 G0

1921.830	277°.1	0″.31	$0^h.9$	2
.839	279.1	0.32	1.4	3
1921.83	278°.1	0″.32	2n	

The quadrant given is correct. The motion may be rapid for Hussey's measures, the only ones published, are:

1900.64	72°.4	0″.24	3n
1902.72	57.0	0.26	3n

1866 β 537

R.A. $3^{h}\ 41^{m}\ 05^{s}$ Decl. +24° 31′

8.8 10.3 A2

1918.690	162°7	0″30	$1^{h}4$	3
1920.628	162.4	0.32	1.5	2
.678	155.6	0.29	1.7	2
.746	159.1	0.26	1.9	2
1920.65	159°0	0″29	3n	

1883 β 1105

R.A. $3^{h}\ 42^{m}\ 36^{s}$ Decl. +23° 52′

9.7 11.0 F8

1920.678	54°3	0″32	$2^{h}0$	2
.746	53.5	0.32	2.7	2
1920.72	53°9	0″32	2n	

1900 OΣ 65

R.A. $3^{h}\ 44^{m}\ 18^{s}$ Decl. +25° 17′

6.0 6.3 A3

1914.676	205°6	0″65	$2^{h}3$	2
.701	205.6	0.64	2.2	3
1917.748	206.6	0.66	2.1	3
1918.690	206.5	0.59	1.5	3
1920.678	208.4	0.59	2.3	2
1917.30	206°4	0″63	5n	

1977 β 1042

R.A. $3^{h}\ 53^{m}\ 40^{s}$ Decl. −2° 56′

9.3 10.5 ——

1913.817	36°9	1″20	$1^{h}0$	2
A and BC	7.2	9.0	G5	
1913.817	93°2	55″50	1.2	2

2007 Σ 483

R.A. $3^{h}\ 57^{m}\ 23^{s}$ Decl. +39° 14′

7.4 9.2 G5

1921.789	183°0	0″73	$1^{h}8$	2
.800	181.1	0.76	0.6	2
1921.79	182°0	0″74	2n	

2026 β 545

R.A. $4^{h}\ 00^{m}\ 44^{s}$ Decl. +37° 46′

8.0 11.0 K0

1917.674	314°7	1″12	$1^{h}7$	3

2027 OΣ 531

R.A. $4^{h}\ 00^{m}\ 54^{s}$ Decl. +37° 49′

7.3 9.1 G5

1917.674	117°5	1″40	$1^{h}5$	3
1921.770	110.2	1.36	1.5	3
.773	108.2	1.32	2.2	3
.800	108.3	1.08	0.8	2
1921.78	108°9	1″25	3n	

2068 OΣ 74

R.A. $4^{h}\ 06^{m}\ 49^{s}$ Decl. +9° 24′

8.3 8.8 F0

1914.701	288°9	0″50	$2^{h}6$	3
.715	288.7	0.50	2.5	3
1914.71	288°8	0″50		
1921.773	287.1	0.51	2.7	3

2075 Hu 302

R.A. $4^{h}\ 07^{m}\ 17^{s}$ Decl. +22° 42′

9.6 9.8 ——

1922.668	360°9	0″24	$2^{h}0$	3
.671	359.1	0.33	1.3	3
1922.67	360°0	0″28	2n	

Hussey, in 1901, recorded the position angle as 164°1 and called the components equal in brightness.

2093 OΣ 77

R.A. $4^{h}\ 09^{m}\ 35^{s}$ Decl. +31° 27′

8.0 8.2 F8

1914.728	222°0	0″46	$1^{h}8$	3
.734	225.4	0.45	1.9	2
1916.817	229.3	0.45	1.6	3
1919.698	232.6	0.50	1.5	3
1921.694	235.5	0.52	2.1	3
.710	235.4	0.50	2.5	3

There are recent orbits by Jackson (*M.N.* **80**, 548, 1920) and Van den Bos (*B.A.N.*, **1**, 82, 1922), the former making the period 95 years and the eccentricity 0.050, the latter, 51.6 years and 0.846! Observations are lacking in years 1890 to 1895, during which Van den Bos assumes a change of quadrant to have taken place and it is impossible, at present, to decide definitely between the two orbits, though the one by Van den Bos gives smaller residuals for these observations:

			(O-C) B		(O-C) J	
Date	θ_0	ρ_0	$\Delta\theta$	$\Delta\rho$	$\Delta\theta$	$\Delta\rho$
1914.73	223°7	0″46	−2°0	+0″09	−3°3	+0″06
1916.82	229.3	0.45	−0.7	+0.06	−2.4	+0.04
1919.70	232.6	0.50	−2.6	+0.08	−5.5	+0.08
1921.70	235.4	0.51	−3.2	+0.08	−7.1	+0.10

2109 Σ 518 o^2 *Eridani* BC

R.A. $4^{h}\ 10^{m}\ 40^{s}$ Decl. −7° 49′

9.4 10.8 B9, Mdp

1917.075	19°1	3″18	$3^{h}4$	2
1921.789	11.0	3.55	2.8	3
.798	11.5	3.52	2.7	3

Using Doolittle's elements (*Proc. Am. Phil. Soc.*, **42**, 170, 1903), I have computed the following residuals:

	Δ_0	θ_0	(O-C) $\Delta\theta$	$\Delta\rho$
1917.08	19°1	3″18	+7°0	+0″46
1921.79	11.2	3.54	+4.4	+0.61

Leonard has recently determined the spectral class of each component of this pair. He finds the brighter star to be of Class

2109—*(Continued)*

B9, substantially confirming the earlier observations of Adams (A0) and Miss Cannon (A). The fainter star is of Class Md, with bright lines of hydrogen and of calcium (H and K). This is a most remarkable combination, since the two stars not only form a binary system, but are physically connected with the bright star (4.48 photometric magnitude) 82″ distant, which is of class G5. The distance residuals indicate that Doolittle's orbit requires correction.

2110 Ho 328

R.A. $4^h\ 11^m\ 11^s$ Decl. +19° 26′

8.1 8.6 F5

1914.761	18°1	0″24	2^h3	3
.819	22.5	0.24	2.9	3
1917.967	19.6	0.36	1.6	2
1918.002	15.7	0.32	5.9	2
1919.668	13.1	0.40	2.2	2
.689	14.1	(0.26)	2.4	2
1921.770	15.5	0.42	1.7	3
.773	10.8	0.40	2.9	3

1914.79	20°3	0″24	2n
1917.98	17.6	0.34	2n
1919.68	13.6	0.40	2, 1n
1921.77	13.2	0.41	2n

In my earlier measures, when the pair was a closer one, the quadrant was indeterminate, but in all of above measures it was noted as certainly north, and the difference in brightness of the two components was estimated at half a magnitude. It is probable that the quadrant has been reversed at least once since Hough's discovery in 1890.

2134 OΣ 79 55 Tauri

R.A. $4^h\ 14^m\ 11^s$ Decl. +16° 17.

7.1 8.9 G0

1914.726	328°4	0″37	2^h1	3
.728	328.6	0.31	1.9	3
.739	327.8	0.38	2.1	2
.742	328.3	0.33	2.7	3
1915.744	330.4	0.31	2.3	4
1917.075	338.3	0.35	4.7	2
1917.967	341.9	0.44	2.3	2
1918.002	344.2	0.41	6.2	2
1919.668	345.8	0.40	2.6	2
.689	344.4	0.46	2.6	2
1921.694	355.3	0.49	2.4	3
.710	350.2	0.46	2.9	3

Comparison with my ephemeris (*Lick. Obs. Publ.* **12**, 30, 1914), gives the following residuals for these measures:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.73	328°3	0.35	−4°6	−0″02
1915.74	330.4	0.31	−6.8	−0.07
1917.08	338.3	0.35	−3.3	−0.04
1917.98	343.0	0.42	−2.6	+0.02
1919.68	345.1	0.43	−6.1	+0.01
1921.70	352.8	0.48	−4.4	+0.02

2154 OΣ 82

R.A. $4^h\ 17^m\ 04^s$ Decl. +14° 49′

7.3 8.8 G0

1913.176	83°4	0″68	6^h1	3
1914.726	75.5	0.71	2.0	3
.728	75.2	0.67	2.2	3
1917.075	71.4	0.72	4.5	3
1921.770	60.1	0.79	2.0	3
.773	58.1	0.80	3.3	3

Hussey regarded his elements (*Lick Obs. Publ.* **5**, 60, 1901) as quite uncertain, but they represent these observations fairly, except the final distance. The residuals are:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1913.18	83°4	0″68	+1°6	+0″01
1914.73	75.4	0.69	−1.7	+0.01
1917.08	71.4	0.72	+1.3	+0.03
1921.77	59.1	0.80	+2.8	+0.12

The residuals for 1912.04, given in *Lick Obs. Publ.* **12**, 31, are in error. Instead of −13°6, −0″14, they should read −6°9, −0″05.

2172 Hu 304 66 *Tauri*

R.A. $4^h\ 18^m\ 25^s$ Decl. +9° 14′

5.8 5.8 A2

1914.715	41°6	0″31	2^h8	3
.726	42.2	0.33	1.9	3
1917.967	49.1	0.34	2.6	2
1918.002	45.9	0.33	5.7	3
1919.730	51.4	0.36	2.9	3
.763	52.8	0.33	3.2	2
1922.707	56.7	0.32	2.7	2
.709	55.4	0.32	2.1	3

1914.72	41°9	0″32	2n
1917.98	47.5	0.34	2n
1919.75	52.1	0.35	2n
1922.71	56.0	0.32	2n

2181 Hu 609

R.A. $4^h\ 19^m\ 43^s$ Decl. +34° 29′

8.7 8.7 F5

1921.871	131°1	0″23	1^h6	2
.932	134.5	0.20	2.0	3
1921.90	132°8	0″22	2n	

There is evidence of rapid motion in this pair, Hussey's measures in 1902 giving 10°3, 0″17.

2187 β 1185

R.A. $4^h\ 20^m\ 02^s$ Decl. +18° 38′

8.2 8.8 G0

1913.176	195°5	0″14	6^h0	2
1914.726	178.3	0.12	2.3	3
.761	171.0	0.12	2.0	3
1915.749	——	<0.10	2.6	4
1919.689	28.5	0.16	2.8	2
.889	20.3	0.21	5.1	3
.960	26.9	0.21	6.1	2

2187—(*Continued*)

1921.773	25°1	0″23	3^{h}1	3
.789	24.9	——	2.2	2
.792	22.3	0.24	2.6	2

THE ORBIT OF β 1185

β 1185 is at all times a very difficult pair to measure for the two components differ more than half a magnitude in brightness and the angular separation at maximum barely exceeds 0″25 while at minimum it falls below the resolving power of the largest telescopes. This will account for the fact that, except for measures by Schiaparelli in 1896, the pair has been measured only with the 36-inch refractor. The quadrant is determinate when the angular separation exceeds 0″15 and it is certain that the companion is now nearly in the same position it held at the time of Burnham's discovery in 1890. The measures are also sufficient to show that there has been but one revolution in the interval, that the orbit plane is inclined at a large angle and that the eccentricity is small. They are not sufficiently numerous to give the values of the elements with great exactness and the orbit here presented is frankly preliminary, though it represents the measures somewhat better than the orbit printed two years ago (in the *Publ. A.S.P.* **33**, 218, 1920) does. The ephemeris shows that measures should be possible during the next two or three years and again about 1930.

ELEMENTS

$P=$ 28.9 years
$T=$1917.8
$e=$ 0.20
$a=$ 0″25
$\omega=$ 301°6
$i=$ 75.65
$\Omega=$ 24.3
$n=-12.4566$

EPHEMERIS

	θ	ρ
1923.80	12°8	0″19
1924.80	7.1	0.17
1925.80	358.9	0.14
1926.80	345.7	0.10
1927.80	322.4	0.08
1928.80	287.5	0.07
1929.80	257.2	0.09
1930.80	215.4	0.12

THE OBSERVATIONS

					(O–C) $\Delta\theta$	$\Delta\rho$
1890.70	25°6	0″16	4n	β	−5°2	−0″03
1896.09	18.0	0.2±	4	Sp	+12.2	+0.06±
1899.92	(352.0)	(0.14)	2	A	(+65.3)	(+0.05)
1906.35	205.6	0.24	4	A	−7.7	−0.01
1908.22	203.2	0.25	3	A	−5.0	−0.02
1911.68	196.3	0.20	2	A	−2.2	−0.03
1913.18	195.5	0.14	1	A	+3.9	−0.04
1914.74	174.6	0.12	2	A	−0.4	+0.02
1919.85	25.2	0.19	3	A	−4.5	−0.01
1921.78	24.1	0.24	3	A	+2.7	+0.02

It is obvious that my measures in 1899 are entirely erroneous and my opinion is that they do not refer to the actual double star image at all but to the spurious elongation produced by atmospheric dispersion. In my search for new double stars I found it necessary to be constantly on guard to prevent mistaking such elongations for extremely close pairs, unless the seeing was of the best quality.

12992 Hu 1080

R.A. 4^h 23^m 16^s Decl. +15° 56′

6.9 7.9 F8

1913.176	251°2	0″33	6^{h}4	3
1914.728	250.6	0.20	2.5	2
.739	249.5	0.25	2.3	2
.742	243.1	0.21	2.8	3
1915.744	257.4	0.11	2.8	3
1917.967	99.9	0.14	2.6	2
1920.119	71.1	0.20	7.2	3
1920.710	79.1	0.32	3.1	3
.773	78.5	0.28	2.2	3
1922.764	79.4	0.29	2.7	2

1913.18	251°2	0″33	1n
1914.74	247.7	0.22	3n
1915.74	257.4	0.11	1n
1917.97	99.9	0.14	1n
1920.12	71.1	0.20	1n
1920.74	78.8	0.30	2n
1922.76	79.4	0.29	1n

It is obvious that some of the angle measures are considerably in error, but the difference in the brightness of the components makes it certain that the companion has described fully half of the apparent orbit since Hussey's discovery in 1904 (263°1, 0″44, 3n).

2230 Σ 554

R.A. 4^h 24^m 26^s Decl. +15° 26′

5.7 9.0 F0

1913.176	29°6	0″81	6^{h}7	2
1914.728	35.8	0.86	2.8	3
.739	29.9	0.98	2.4	2
.742	32.7	0.97	2.9	3
1917.075	29.3	0.88	4.3	2
1920.119	27.8	0.85	7.0	3
1921.710	30.7	1.01	3.2	3
.770	29.6	1.00	2.3	3

The following comparison is with the orbit by Van den Bos (*M.N.* **81**, 474, 1921):

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1913.18	29°6	0″81	−1°8	−0″02
1914.74	32.8	0.94	+2.5	+0.06
1917.08	29.3	0.88	+0.4	−0.07
1920.12	27.8	0.85	+0.3	−0.19
1921.74	30.2	1.00	+3.5	−0.09

J.C. 664 Jonckheere 709

R.A. 4^h 24^m 43^s Decl. −3° 48′

9.7 9.7 ——

1914.676	90°7	1″51	3^{h}8	2
.775	89.9	1.45	3.7	2
1914.73	90°3	1″48	2n	

12998 Hu 1083

R.A. $4^h\ 28^m\ 27^s$ Decl. +62° 46′

8.9 9.9 F2

1922.814	144°.3	0″.26	$1^h.7$	2
.890	146.5	0.30	2.5	2
1922.85	145°.4	0″.28	2n	

2256 Lewis 4

R.A. $4^h\ 29^m\ 51^s$ Decl. +19° 41′

6.6 F8

1910.776 } On these nights and on several others this star
1921.904 } and other stars in the vicinity were carefully examined with the 36-inch telescope. No pair answering Lewis's description could be found.

2262 Hu 610

R.A. $4^h\ 29^m\ 52^s$ Decl. +34° 00′

8.9 9.2 ——

1921.871	82°.9	0″.24	$1^h.9$	2
.932	80.7	0.25	2.2	3
1921.90	81°.8	0″.24	2n	

Hussey's observations in 1902.79 gave 28°.4, 0″.15.

2266 β 1031

R.A. $4^h\ 30^m\ 11^s$ Decl. +16° 18′

10.6 13.0 ——

1921.789	273°.8	1″.54	$3^h.1$	2
.798	274.8	1.50	3.1	3
1921.79	274°.3	1″.52	2n	

2274 Σ 565

R.A. $4^h\ 31^m\ 07^s$ Decl. +41° 55′

7.5 8.8 K0

1917.956	171°.4	1″.42	$3^h.4$	3

2279 β 1295 2 *Camelopardi*

R.A. $4^h\ 32^m\ 03^s$ Decl. +53° 17′

5.4 7.4 F0

1919.807	159°.5	0″.29	$1^h.4$	2
1921.710	154.9	0.34	2.0	3
.798	157.0	0.28	2.6	3
1921.75	156.0	0″.31	2n	

AB and C = Σ 566 7.4

1921.710	276°.2	1″.24	$2^h.2$	3
.798	271.6	1.33	2.8	3
1921.75	273°.9	1″.28	2n	

2335 Hu 612

R.A. $4^h\ 39^m\ 53^s$ Decl. +53° 07′

7.0 9.0 F2

1921.798	250°.9	0″.25	$2^h.9$	3
.800	252.8	0.25	1.2	3
.830	256.0	0.25	1.2	2
1921.81	253°.2	0″.25	3n	

Earlier measures are:

1902.69	198°.4	0″.22	3n	Hu
1906.76	208.4	0.27	2n	A

2381 β 883

R.A. $4^h\ 45^m\ 40^s$ Decl. +10° 54′

7.7 7.7 F5

1914.739	38°.0	0″.32	$2^h.7$	2
.742	40.1	0.38	3.0	3
.761	42.1	0.30	2.7	3
1915.744	50.8	0.30	3.0	4
1917.967	76.8	0.25	3.0	2
1918.002	68.6	0.25	6.5	2
1920.111	99.2	0.22	5.5	2
1920.754	116.0	0.20	2.7	2
.760	113.6	0.19	3.6	3
1921.789	134.4	0.16	2.4	2
.798	142.0	0.14	3.3	3
.844	137.8	0.14	3.2	3

Comparison with the places computed from my orbit (*Lick Obs. Publ.* **12**, 35, 1914) gives the following residuals:

	θ_0	ρ_0	(O–C) Δθ	Δρ
1914.75	40°.1	0″.33	+1°.3	+0″.06
1915.74	50.8	0.30	+2.8	+0.03
1917.98	72.7	0.25	+2.6	−0.01
1920.11	99.2	0.22	+1.3	+0.01
1920.76	114.8	0.20	+5.7	+0.01
1921.81	138.1	0.15	−2.4	±0.00

2383 β 552

R.A. $4^h\ 46^m\ 11^s$ Decl. +13° 29′

6.7 10.0 F5

1914.742	253°.4	0″.68	$3^h.1$	3
.761	253.3	0.69	2.5	3
1915.744	253.7	0.69	3.2	4
1917.967	260.0	0.71	3.2	2
1920.111	266.1	0.65	5.8	2
.754	266.6	0.65	2.9	3
.760	264.7	0.64	3.8	3
1921.844	269.6	0.73	3.4	3
.852	267.7	0.71	2.4	3

The first orbit for this binary was See's (*Mon. Not. R.A.S.* **68**, 198, 1908). He derived a period of 56.0 years, and an eccentricity of 0.345. In 1919 I computed the elements given below, using Zwiers's graphical method. Elements have also been computed recently by Russell and by Jackson with results that differ but little from mine. Inspection of the table of measures (which is arranged to indicate the grouping used in the orbit computation) shows that a small arbitrary change in the value of the node would reduce the sum of the squares of the angle residuals. Such a change, however, really involves slight changes in other elements, and it seems preferable to defer these until a longer arc permits the computation of more nearly definitive elements.

Assuming the mass to be 1.7⊙ the hypothetical parallax is +0″.024, which is in good agreement with the spectroscopic parallax (+0″.028) and the latest relative trigonometric parallax (+0″.019, Miller).

2383—(*Continued*)

ELEMENTS

P = 86.0 years
T = 1886.35
e = 0.51
a = 0.56
ω = 309°.6
i = 39.35
Ω = 145.8
n = +4.186

EPHEMERIS

	θ	ρ
1923.35	272°.6	0″.70
1925.35	276.1	0.71
1927.35	279.4	0.72
1929.35	282.7	0.74
1931.35	285.9	0.75
1933.35	289.0	0.75
1935.35	292.0	0.76
1937.35	295.0	0.76
1939.35	298.0	0.76

THE OBSERVATIONS

					(O–C)	
					Δθ	Δρ
1874.95	340°∓	0″.5±	1n	β	−2°.9∓	+0″.02±
1877.97	360∓	(0.8±)	1	β	+3.1	(+0.42±)
1886.19	(265?)	0.5±	1	HΣ	(−15.3)	(+0.26±)
1889.19	144.7	0.35±	1	Sp	+6.7	+0.05±
1890.96	156.7	0.33	3	β	+3.0	±0.00
1891.13	153.8	0.3±	8	Sp	−1.3	−0.03±
1893.07	165.3	0.35±	1	Sp	−3.8	−0.01±
1894.15	178.2	0.38	2	Sp	+2.1	+0.01
1894.88	177.0	0.40	2	Bar	−3.5	+0.01
1896.11	179.9	0.35±	7	Sp	−8.1	−0.05±
1896.84	187.7	0.43	1	Hu	−3.9	+0.03
1896.88	186.2	0.40	3	A	−5.6	±0.00
1897.13	193.5	0.25±	2	Sp	+0.4	−0.16±
1897.82	193.7	0.44	5	A	−2.9	+0.03
1897.95	193.4	0.43	3	Hu	−3.9	+0.01
1898.00	191.0	0.42	2	Gr	−6.4	±0.00
1898.12	197.2	0.43	3	A	−1.0	±0.00
1898.74	199.1	0.45	3	A	−2.1	+0.02
1899.16	206.1	0.37	1	Gr.	+2.9	−0.06
1899.75	202.3	0.60	1	See	−3.6	+0.16
1899.79	202.8	0.45	3	A	−3.3	+0.01
1900.18	207.9	0.45	2	Gr	±0.0	+0.01
1900.48	204.0	0.43	4	See	−5.2	−0.01
1900.64	205.4	0.41	3	A	−4.5	−0.04
1900.78	203.2	0.49	3	Doo	−7.3	+0.04
1901.72	205.8	0.43	2	A	−8.7	−0.03
1901.98	203.3	0.56	2	Doo	−12.3	+0.10
1902.14	211.4	0.40	1	Com	−4.9	−0.06
1902.74	229.3	0.32	1	β	+10.7	−0.15
1903.14	220.0	0.40	4	A	−0.2	−0.07
1903.17	223.0	0.42	3	Com	+2.7	−0.05
1904.19	217.8	0.52	2	van Bies	−6.4	+0.03
1904.98	227.2	0.42	2	A	+0.2	−0.08
1905.90	227.9	0.46	2	A	−2.3	−0.05
1908.01	240.0	0.57	5	Doo	+3.0	+0.04
1908.12	236.6	0.52	2	Com	−0.8	−0.01
1908.15	239.7	0.42	1	A	+2.2	−0.11

OBSERVATIONS—(*Continued*)

					(O–C)	
					Δθ	Δρ
1908.84	234°.6	0″.50	2	A	−4°.9	−0″.04
1909.08	250.7	0.53	1	van Bies	+10.4	−0.01
1909.18	231.0	0.48	1	Gr	−9.6	−0.07
1912.91	247.8	0.66	2	A	−2.9	+0.07
1913.02	247.2	0.56	3	van Bies	−3.7	−0.03
1914.75	253.4	0.68	2	A	−1.7	−0.07
1915.74	253.7	0.69	1	A	−3.6	+0.07
1915.86	257.4	0.56	3	Com	−0.2	−0.06
1917.97	260.0	0.71	1	A	−2.2	+0.07
1920.54	265.8	0.65	3	A	+1.5	−0.02
1921.85	268.6	0.72	2	A	−1.3	+0.04

2382 Hu 819

R.A. $4^h\ 46^m\ 17^s$ Decl. +35° 38′

8.9 9.4 A0

1921.932	291°.8	0″.26	$2^h.4$	3
1922.668	287.0	0.25	1.6	3
1922.30	289°.4	0″.26	2n	

2397 Hu 555

R.A. $4^h\ 50^m\ 06^s$ Decl. +51° 56′

8.8 9.0 ——

1922.671	28°.2	0″.20	$1^h.6$	2
.707	25.8	0.22	2.3	2
1922.69	27°.0	0″.21	2n	

AB and C = Σ608 —— 9.2

1922.671 115°.2 4″.26 1.8 2

For the close pair Hussey's measures give: 1902.71, 309°.6, 0″.16. I have adopted his estimate of the difference of magnitude in the components.

2497 β 749

R.A. $4^h\ 59^m\ 15^s$ Decl. +55° 24′

7.6 9.6 F8

1917.694	231°.4	0″.96	$2^h.4$	3
1919.807	230.5	0.99	2.1	2
1918.75	231°.0	0″.98	2n	

2503 Σ 635

R.A. $4^h\ 59^m\ 40^s$ Decl. +54° 51′

8.6 8.6 B9

1917.694	292°.8	0″.69	$2^h.3$	3
1919.807	293.1	0.76	1.9	2
1918.75	293°.0	0″.72	2n	

13037 Hu 1097

R.A. $5^h\ 00^m\ 30^s$ Decl. +76° 21′

6.3 10.2 B9

1922.731	113°.7	1″.58	$2^h.7$	3
.734	114.5	1.58	2.1	2
1922.73	114°.1	1″.58	2n	

2535 OΣ 98 *ι Orionis*

R.A. $5^{h}\,02^{m}\,26^{s}$ Decl. +8° 22′

5.9 6.7 Fop

1914.739	147°6	0″82	$2^{h}8$	2
.742	145.8	0.84	3.3	3
1920.119	138.8	0.84	7.4	3
1921.792	134.1	0.77	3.1	2
.798	134.5	0.76	3.5	3
1914.74	146°7	0″83	2n	
1920.12	138.8	0.84	1n	
1921.79	134.3	0.76	2n	

Miss Cannon notes that the spectrum is composite, and thinks it probable that the fainter component belongs to Class A2 or A3.

2544 β 1047

R.A. $5^{h}\,03^{m}\,28^{s}$ Decl. +27° 54′

8.7 9.2 ——

1914.819	83°1	0″33	$3^{h}2$	3
.890	81.8	0.33	3.2	3
1914.85	82°4	0″33	2n	

A and BC = Σ 645

6.0 8.2 A3

1914.819	27°0	11″72	$3^{h}4$	3

2571 Hu 33

R.A. $5^{h}\,06^{m}\,33^{s}$ Decl. +0° 24′

7.1 7.6 B9

1921.023	305°6	0″14	$5^{h}6$	3
.694	308.7	0.15	4.0	2
1921.36	307°2	0″15	2n	

Hussey gives 324°2, 0″16, for the date 1899.09.

2605 β 555

R.A. $5^{h}\,09^{m}\,44^{s}$ Decl. −8° 19′

8. ——

The companion to *Rigel* was examined on many nights in the years 1915 to 1920 but on one night only (1915.744) was there any indication of elongation. If real, the distance on this night was less than 0″10 and the estimated angle (298°±) is therefore very uncertain.

2712 Da 5 *η Orionis*

R.A. $5^{h}\,19^{m}\,27^{s}$ Decl. −2° 29′

3.7 4.9 B1

1921.242	77°3	1″27	$8^{h}8$	2
.792	79.8	1.27	3.8	2
1921.52	78°6	1″27	2n	

2780 Σ 728 32 *Orionis*

R.A. $5^{h}\,25^{m}\,26^{s}$ Decl. +5° 52′

4.6 6.1 B3

1914.761	99°3	0″24	$3^{h}0$	3
.890	104.6	0.23	3.7	3
1917.899	90.1	0.24	4.5	2
1921.773	80.0	0.31	4.3	2
.825	82.3	0.30	3.6	2
1914.83	102°0	0″24	2n	
1917.90	90.1	0.24	1n	
1921.80	81.2	0.30	2n	

2815 Tucker 2

R.A. $5^{h}\,28^{m}\,51^{s}$ Decl. +13° 56′

8.4 10.1 A0

1916.858	51°6	4″70	$4^{h}3$	2

2857 β 1240 26 *Aurigae*

R.A. $5^{h}\,32^{m}\,13^{s}$ Decl. +30° 26′

6.0 6.4 A2

1914.890	300°0	0″14	$3^{h}4$	3
1915.005	295.4	0.15	3.2	3
1914.95	297°7	0″14	2n	

In 1921 the pair was found to be too close for satisfactory measures.

2874 Hu 825

R.A. $5^{h}\,33^{m}\,20^{s}$ Decl. +35° 57′

8.3 8.6 A0

1921.932	344°5	0″41	$2^{h}6$	2
1922.745	344.1	0.37	3.3	2
1922.34	344°3	0″39	2n	

13073 Hu 1109

R.A. $5^{h}\,33^{m}\,21^{s}$ Decl. +66° 30′

9.2 10.0 A2

1922.731	157°5	0″29	$3^{h}0$	3
.734	156.1	0.29	2.6	2
1922.73	156°8	0″29	2n	

AB and C = Σ 739 —— 9.8

1922.731	247°9	2″14	$3^{h}2$	3

2883 β 1032 *σ Orionis*

R.A. $5^{h}\,33^{m}\,44^{s}$ Decl. −2° 39′

3.9 5.9 B0

1916.130	305°5	0″25	$4^{h}8$	3
.147	310.0	0.26	5.4	2
1916.14	307°8	0″26	2n	

2896 β 1007 126 *Tauri*

R.A. $5^{h}\,35^{m}\,31^{s}$ Decl. +16° 29′

5.6 5.6 B3

1914.890	103°±	0″10	$4^{h}0$	3
1915.744	83±	<0.10	3.7	4
1918.980	No elongation		3.8	4

Powers to 3000 were used. In 1914 the elongation was recorded as "definite," in 1915 as "suspected." In 1918 the star image seemed quite round.

13079 Hu 1112

R.A. $5^{h}\,40^{m}\,18^{s}$ Decl. +82° 44′

7.9 8.5 F8

1922.731	298°6	0″19	$2^{h}4$	2
.734	296.7	0.20	1.4	2
1922.73	297°6	0″20	2n	

Hussey gives: 1905.02, 322°6, 0″23, 2n.

2977 β 560

R.A. $5^h\ 42^m\ 54^s$ Decl. +29° 42′

8.5 8.5 A5

1919.993	152°.8	1".10	3^h.1	3
1921.792	147.8	1.01	3.7	2
.800	147.2	0.97	2.3	3
1921.80	147°.5	0".99	2n	

3078 OΣ 124

R.A. $5^h\ 53^m\ 16^s$ Decl. +12° 48′

5.8 G5–A5

1921.869 } Possibly an extremely close pair, with slight
.904 } elongation in north—preceding to south—following direction.

Miss Cannon notes the spectrum as composite. The star has not been seen double by any observer since 1873.

3134 Hu 450

R.A. $5^h\ 59^m\ 56^s$ Decl +23° 31′

8.8 10.3 B9

1921.932	235°.4	0".46	3^h.6	2
1922.786	236.7	0.50	3.6	3
1922.36	236°.0	0".48	2n	

No change since Hussey's measures in 1902. His single night's measure in 1900 is probably in error.

3276 Ho 229

R.A. $6^h\ 12^m\ 24^s$ Decl. +14° 25′

6.0 12.5 A0

1914.027	325°.5	2".31	4^h.2	2

J.C. 1176 Jonckheere 687

R.A. $6^h\ 12^m\ 58^s$ Decl. +7° 48′

9.5 9.5 A0

1914.011	351°.1	1".91	8^h.4	3
.120	350.8	1.92	5.4	2
1914.07	351°.0	1".92	2n	

3291 β 895

R.A. $6^h\ 13^m\ 39^s$ Decl. +28° 28′

7.8 7.8 A3

1917.992	273°.7	0".15	4^h.7	3
1919.862	278.6	0.15	4.8	3
.988	271.3	0.15	5.0	2
1921.850	287.1	0.18	3.7	3

1917.99	273°.7	0".15	1n
1919.92	275.0	0.15	2n
1921.85	287.1	0.18	1n

The companion has described an arc of at least 140°, and possibly 320° since Burnham's first measures in 1879; but the observations are few and there are no measures at all in the intervals 1879-1887 and 1891-1900. No safe deduction as to the period or other orbit elements can therefore be made at this time.

J.C. 1261 Jonckheere 691

R.A. $6^h\ 25^m\ 34^s$ Decl. +4° 43′

9.2 10.5 A0

1914.214	200°.8	0".99	9^h.0	3
.252	199.6	1.02	8.1	3
1914.23	200°.2	1".00	2n	

3560 Ho 237

R.A. $6^h\ 36^m\ 50^s$ Decl. +3° 21′

7.0 A2

1913.73 } The star appeared round with powers to 1000
1921.82 } and had the characteristic diffraction pattern of a single star, not of a very close double. Doolittle and Burnham found it single in the years 1901-06, and there is no record of it as double since Hough's announcement in 1887. It is probably single.

3561 β ——

R.A. $6^h\ 36^m\ 45^s$ Decl. −11° 13′

8.3 12.5 A0

1913.814	342°.4	1".94	6^h.6	2

A and C (11.5) = H 2337

1913.814	101°.8	18".84	6.8	2

J.C. 1354 Jonckheere 667

R.A. $6^h\ 38^m\ 53^s$ Decl. +7° 32′

9.1 10.7 ——

1913.852	68°.9	3".41	4^h.6	2
1914.120	70.4	3.44	5.6	2
1913.99	69°.6	3".42	2n	

3596 A.G.C. 1 *Sirius*

R.A. $6^h\ 40^m\ 45^s$ Decl. −16° 35′

−1.6 8.5 A0, F

1913.127	82°.0	9".78	6^h.8	2
.233	81.4	10.26	7.9	3
1914.978	77.0	10.94	6.5	3
1915.202	75.3	10.67	6.8	2
.224	76.3	10.62	7.3	2
1917.970	71.0	11.07	7.7	3
.989	72.3	11.32	7.5	3
1918.090	69.9	11.09	6.5	3
.110	70.6	11.13	6.3	4
1918.977	69.0	11.16	7.0	2
.988	69.0	11.12	7.2	3
1919.977	67.6	11.07	7.3	4
1920.092	68.1	11.08	7.4	2
1920.952	65.5	11.35	6.9	3
.990	65.2	11.06	7.4	3
.998	67.1	11.29	7.6	2
1921.798	62.9	11.26	6.7	3
1922.025	65.0	11.05	8.2	3
.030	63.8	11.06	8.1	2

The companion is now very nearly at its maximum apparent distance from the primary star. Estimates of brightness, made with special care, show that it is fully 8.5 magnitude. Following is the comparison of the measures with my ephemeris (*L.O. Bull.* **9**, 184, 1918.)

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1913.18	81°.7	10".02	−0°.3	+0".09
1915.13	76.2	10.74	−1.3	+0.30
1918.04	71.0	11.15	−0.3	+0.16
1918.98	69.0	11.14	−0.4	+0.03
1920.03	67.8	11.08	+0.4	−0.13
1920.98	65.9	11.23	+0.3	−0.05
1921.95	63.9	11.12	+0.2	−0.21

3625 Σ 963

R.A. $6^{h}\ 44^{m}\ 16^{s}$ Decl. +59° 34′

5.8 7.0 F5–A2

1916.204	96°.7	0″.28	$10^{h}.0$	2
.700	91.9	0.31	4.7	3
1916.45	94°.3	0″.30	2n	

According to Miss Cannon the spectrum is composite.

—— A. G. Berlin A 2682

R.A. $7^{h}\ 06^{m}\ 30^{s}$ Decl. +18° 49′

9.2 9.2 ——

1913.184	184°.0	1″.12	$9^{h}.0$	3
.307	183.5	1.09	10.3	2
1913.25	183°.8	1″.10	2n	

Not in Burnham's G. C. nor in Jonckheere's Catalogue.

3939 Küstner 28

R.A. $7^{h}\ 10^{m}\ 51^{s}$ Decl. +5° 45′

9.2 10.1 A0

1914.810	319°.7	1″.12	$6^{h}.9$	3
.852	321.3	1.18	7.6	2
1914.83	320°.5	1″.15	2n	

J.C. 1595 A.G. ——

R.A. $7^{h}\ 24^{m}\ 23^{s}$ Decl. +25° 59′

9.4 9.4 ——

1921.836	171°.6	1″.90	$6^{h}.4$	3

J.C. 1603 A.G. ——

R.A. $7^{h}\ 24^{m}\ 53^{s}$ Decl. +25° 22′

9.0 10.0

1921.836	296°.6	3″.49	$6^{h}.5$	3

4187 Schaeberle 1 *Procyon*

R.A. $7^{h}\ 34^{m}\ 04^{s}$ Decl. +5° 29′

0.5 13.5 F5

1921.825	Companion invisible		$7^{h}.6$	3

Schaeberle's faint companion was looked for on many other good nights in the years 1910 to 1921, but without success.

4310 β 101 9 *Argus*

R.A. $7^{h}\ 47^{m}\ 09^{s}$ Decl. −13° 38′

5.6 6.2 G0

1916.127	No certain elongation		$8^{h}.1$	3
1917.970	286°.0	0″.46	8.2	2
.989	284.3	0.43	7.7	3
1917.98	285°.2	0″.44	2n	

According to my ephemeris (*Lick Obs. Publ.* **12**, 52, 1914) the companion was at periastron in 1915.94, with an apparent distance of 0″.10 from the primary. The computed position for 1917.98 is 283°.6, 0″.50.

4355 OΣ 185

R.A. $7^{h}\ 52^{m}\ 08^{s}$ Decl. +1° 24′

7.1 7.3 F8

1920.839	48°.8	0″.21	$8^{h}.0$	3
.990	51.3	0.27	10.3	3
1921.157	50.2	0.22	9.5	2
1921.00	50°.1	0″.23	3n	

Jackson computed an orbit for this system on the assumption that a revolution has been completed since Otto Struve's discovery in 1843. His ephemeris gives the position for 1921.00 as 192°.7, 0″.08, hence it is clear that the fundamental assumption is incorrect.

4414 β 581

R.A. $7^{h}\ 58^{m}\ 50^{s}$ Decl. +12° 35′

8.6 8.6 G5

1916.125	136°.8	0″.39	$10^{h}.4$	3
.204	135.0	0.42	9.0	3
1916.16	135°.9	0″.40	2n	
1921.869	172.2	0.35	7.1	3

The residuals resulting from comparison with my ephemeris (*Lick Obs. Publ.* **12**, 53, 1914) are +8°.4, −0″.04 and +16°.2 −0″.07, respectively.

4668 β 205

R.A. $8^{h}\ 28^{m}\ 46^{s}$ Decl. −24° 16′

6.9 7.0 A5

1916.204	206°.1	0″.48	$9^{h}.4$	2
1917.989	203.9	0.50	8.0	3
1917.10	205°.0	0″.49	2n	

4714 β 208

R.A. $8^{h}\ 34^{m}\ 45^{s}$ Decl. −22° 19′

5.2 8.5 G5

1916.204	196.8	0″.80	$9^{h}.6$	2
1917.989	197.0	1.13	8.3	3
1917.10	196°.9	0″.96	2n	

J.C. 1810 A. G. Cambridge 4660

R.A. $8^{h}\ 36^{m}\ 06^{s}$ Decl. +25° 22′

9.6 9.8 ——

1917.999	37°.9	3″.00	$10^{h}.1$	2

Noted as "close double" in the *A.G.*, but not given in Burnham's *G.C.* Also listed as Jonckheere 1110.

4771 Schiaparelli —— ε *Hydrae*

R.A. $8^{h}\ 41^{m}\ 29^{s}$ Decl. +6° 47′

3.7 5.2 F8

1914.219	265°.0	0″.18	$10^{h}.8$	3
.299	265.8	0.21	11.0	3
1914.843	270.6	0.16	8.6	4
.852	280.6	0.16	8.8	3
1916.125	Too close to measure			
1917.973	130.3	0.18	10.2	3
1918.110	137.9	0.19	10.7	3
1921.116	163.9	0.19	10.4	2
.119	165.3	0.27	10.2	3
1921.825	175.6	0.25	8.2	3

AB and C = Σ 1273 3.5 7.5

1917.973	241.6	3.11	10.4	3

According to my ephemeris (*Publ. Lick Obs.* **12**, 60, 1912) the close pair was at the point of periastron passage in 1916.27, with an angular separation of only 0″.08. The residuals for the measures in other years are:

4771—(*Continued*)

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.26	265°.4	0″.20	+6°.5	+0″.01
1914.85	275.6	0.16	+6.0	−0.01
1918.04	134.1	0.19	+8.7	+0.01
1921.12	164.6	0.23	−1.8	−0.01
1921.82	175.6	0.25	+2.8	+0.01

J.C. 1839 Vanderdonck 3

R.A. $8^h 45^m 19^s$ Decl. +8° 14′

9.7 9.8 ——

1914.898	88°.3	1″.83	$8^h.5$	3
1915.177	89.3	1.87	10.1	2
1915.224	88.7	1.93	10.2	2
1915.10	88°.8	1″.88	3n	

5005 Σ 3121

R.A. $9^h 11^m 57^s$ Decl. +29° 00′

7.9 8.2 K0

1918.318	219°.6	0″.43	$11^h.2$	2

See's orbit (*Steller's Systems* I, 96, 1896) gives for this date 225°.1, 0″.46.

—— Miller ——

R.A. $9^h 36^m 26^s$ Decl. +2° 58′

9.2 11.2 F8

1913.242	192°.8	4″.60	$11^h.7$	2

Discovered, but not measured, by J. A. Miller. No other measures. Not in Burnham's G.C. nor in Jonckheere's Catalogue.

5223 OΣ 208 *φ Ursae Maj.*

R.A. $9^h 45^m 18^s$ Decl. +54° 32′

5.2 5.5 A2

1917.896	320°.3	0″.47	$6^h.7$	3
1921.272	323.5	0.48	11.9	2
.395	324.7	0.43	12.8	2
1921.33	324°.1	0″.46		

Jackson's ephemeris (*M.N.* **80**, 549, 1920) gives the residuals (O–C) +3°.2, +0″.06 and +2°.1, +0″.03, respectively, for these measures.

5235 A.C. 5 8 *Sextantis*

R.A. $9^h 47^m 33^s$ Decl. −7° 38′

5.8 6.1 A2

1917.061	62°.1	0″.48	$11^h.1$	2
.066	70.7	0.51	10.9	2
1921.242	61.1	0.61	9.2	2
.357	68.2	0.56	11.2	2

Comparison with places computed from Schroeter's elements (*A.N.* **178**, 189, 1908) follows:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1917.06	66°.4	0″.50	+8°.7	−0″.11
1921.30	64.6	0.58	+12.8	−0.02

5250 A.G. 170

R.A. $9^h 50^m 17^s$ Decl. +8° 35′

10.0 10.0 F2

1914.342	218°.6	1″.49	12.5	2
.381	220.4	1.50	13.5	3
1914.36	219°.5	1″.50	2n	

5421 Σ 1429

R.A. $10^h 19^m 32^s$ Decl. +25° 07′

8.8 9.0 G5

1918.241	237°.6	0″.71	$13^h.6$	2

5515 OΣ 224

R.A. $10^h 34^m 28^s$ Decl. +9° 22′

8.0 10.0 F5

1915.224	279°.6	0″.50	$11^h.8$	2
1921.039	266.8	0.50	12.0	3

5652 β 1077 *α Ursae Maj.*

R.A. $10^h 57^m 34^s$ Decl. +62° 17′

2.0 11.0 K0

1921.239 Companion not visible, seeing good.

J.C. 2097 Jonckheere 1011

R.A. $11^h 07^m 40^s$ Decl. +5° 26′

9.6 9.8 ——

1914.217	68°.0	2″.85	$13^h.1$	4
.378	74.2	2.75	14.0	3
1914.30	71°.1	2″.80	2n	

5707 Σ 1517

R.A. $11^h 08^m 26^s$ Decl. +20° 41′

7.5 7.5 G0

1916.303	252°.5	0″.31	$12^h.9$	2
1918.413	255.4	0.28	13.8	2
1921.357	249.9	0.26	13.1	2
1918.69	252°.6	0″.28	3n	

5734 Σ 1523 *ξ Ursae Maj.*

R.A. $11^h 12^m 51^s$ Decl. +32° 06′

4.4 4.9 G0

1918.318	104°.7	2″.87	13.2	2
1919.257	104.0	2.82	14.2	2
.268	104.5	2.80	14.3	2
1919°.26	104°.2	2″.81	2n	

Nörlund's elements (*A.N.* **170**, 121, 1905) give for these two dates, respectively, the positions, 107°.7, 3″.02 and 105°.7, 2″.99.

5811 OΣ 235

R.A. $11^h 26^m 41^s$ Decl. +61° 38′

5.8 7.1 F5

1921.239	207°.9	0″.39	$14^h.2$	3
.436	307.5	0.55	13.8	2
1921.34	307.7	0″.47	2n	

The ephemeris position for this date (*Publ. Lick Obs.* **12**, 72, 1914) is 314°.1, 0″.59.

5841 Σ 1555

R.A. 11ʰ 31ᵐ 02ˢ Decl. +28° 20′

6.4 6.8 A3

1918.359	8°2	0″20	14ʰ4	2
1919.150	8.6	0.19	13.9	3
1921.357	16.4	0.19	13.3	2
.436	13.4	0.20	14.0	2

1918.75	8°4	0″20	2n
1921.40	14.9	0.20	2n

The relative motion since 1829 is still, as Burnham found it in 1906, nearly rectilinear and uniform but the system is probably a physical one.

5848 β 456

R.A. 11ʰ 31ᵐ 46ˢ Decl. −11° 48′

9.9 10.2 G5

1917.973	30°8	0″49	12.0	3
1918.164	32.7	0.39	12.7	2
1920.333	36.9	0.45	13.5	3
.380	38.6	0.48	12.0	2

1918.07	31°8	0″44	2n
1920.36	37.8	0.46	2n

5888 β 917

R.A. 11ʰ 38ᵐ 26ˢ Decl. +11° 15′

8.5 11.5 A5

1913.384	176°3	3″72	14ʰ5	2

5891 Hu 465

R.A. 11ʰ 38ᵐ 32ˢ Decl. −17° 32′

8.1 11.5 F5

1920.275	116°1	0″49	11ʰ7	3
.333	121.2	0.39	12.9	3
1920.30	118°6	0″44	2n	

5951 β 794

R.A. 11ʰ 48ᵐ 19ˢ Decl. +74° 19′

7.1 8.1 F8

1916.289	344°7	0″21	12ʰ5	2
.398	339.6	0.23	10.7	2
1921.239	18.0	0.30	14.8	3
.398	19.8	0.34	14.6	4

An orbit was computed for this pair in 1912, when the observed arc was only 170° (*Lick Obs. Publ.* **12**, 76, 1914). Under such conditions a variety of ellipses satisfy the measures equally well and it is natural to select the one giving the shortest period. This was done though it was recognized that later measures might require large changes in the elements. It is now clear that the period is decidedly longer than the one adopted in 1912, and the eccentricity smaller. The present orbit, computed by Zwiers's method, while it is a better approximation, must also be regarded as preliminary.

ELEMENTS

$P =$ 63.1 years
$T =$ 1911.0
$e =$ 0.41
$a =$ 0″34
$\omega =$ 126°9
$i =$ 34.5
$\Omega =$ 149.7
$n = +$ 5.705

EPHEMERIS

1923.3	29°5	0″30
1925.3	40.0	0.32
1927.3	49.6	0.33
1929.3	58.3	0.34
1931.3	66.3	0.36
1933.3	73.7	0.37
1935.3	80.6	0.39

MEASURES AND RESIDUALS

					(O–C)	
	θ_0	ρ_0			$\Delta\theta$	$\Delta\rho$
1881.34	106°6	0″42	5n	β	−0°4	−0″01
1885.85	119.0	0.50	3	HΣ	+0.2	+0.06
1889.37	133.3	0.41	2	Com	+5.3	−0.02
1890.35	126.9	0.50	4	β	−3.7	+0.07
1891.30	133.4	0.43	3	β	+0.2	+0.01
1892.15	136.9	0.42	3	β	+1.3	±0.00
1892.40	135.7	0.4±	1	Sp	−0.6	−0.02±
1897.41	153.8	0.32	2	Com	+1.3	−0.05
1898.28	157.9	0.40	2	Com	+2.1	+0.05
1898.31	160.7	0.37	2	β	+4.8	+0.02
1898.57	162.6	0.40	3	A	+5.6	+0.05
1899.33	169.9	0.33	2	Brown	+8.8	−0.01
1899.43	166.0	0.40	2	Com	+5.4	+0.06
1900.30	164.8	0.33	2	A	+0.2	+0.01
1901.41	168.5	0.25	3	Com	−1.8	−0.05
1901.53	179.0	0.28	2	A	+8.1	−0.02
1902.44	183.6	0.20	1	A	+7.4	−0.08
1902.79	184.1	0.43	4	Doo	+5.6	+0.15
1903.32	179.3	0.20	1	Com	−2.8	−0.07
1903.33	184.5	0.21	1	A	−0.4	−0.06
1903.70	190.2	0.33	6	van Bies	+5.3	+0.08
1905.28	206.4	0.20	2	A	+7.8	−0.02
1905.42	197.2	0.45	3	Lau	−2.8	+0.23
1907.11	221.8	0.22	1	A	+1.8	+0.03
1908.13	231.9	0.22	2	A	−3.0	+0.04
1908.13	236.±	<0.2	2	Doo	+1.1±	±0.0
1911.53*	285.2*	0.16*	2	A	−2.0	−0.02
1916.34	342.2	0.22	2	A	−0.7	−0.02
1921.32	18.9	0.32	2	A	+0.9	+0.03

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* One night's measure (1911. 336, 266°4, 0″13) was rejected in forming this mean.

6028 Σ 3123

R.A. 12^h 01^m 00^s Decl. +69° 15′

7.9 7.9 F5

1916.289	155°6	0″31	13^h0	2
.339	158.6	0.37	11.7	2
1921.239	148.0	0.38	15.3	3
.420	151.4	0.35	14.4	3

1916.31	157°1	0″34	2n
1921.33	149.7	0.36	2n

AB and C = Barnard — 7.1 15.5

1916.339	311°4	2″97	11^h5	2
1921.239	304.9	3.20	15.5	3

6158 Σ 1639

R.A. 12^h 19^m 26^s Decl. +26° 08′

6.6 7.8 A5

1914.482	343°8	0″57	14.6	3
.504	342.3	0.64	15.6	3
1914.49	343°0	0″60	2n	

Jackson's orbit (*M.N.* **80**, 550, 1920) represents this position with residuals of only ±0°0; +0″02.

6181 OΣ 251

R.A. 12^h 24^m 09^s Decl. +31° 57′

8.4 9.4 G0

1914.482	11°0	0″24	14^h8	3
.504	18.4	0.27	15.7	3
1921.329	20.2	0.21	14.7	3
.357	23.6	0.27	14.4	2

1914.49	14°7	0″26	2n
1921.34	21.9	0.24	2n

My measures from 1909 to 1921 indicate slow direct angular motion, without marked change in the distance; but the many negative results obtained by other observers in earlier years make it possible that the revolution period is short.

6406 Σ 1728 42 *Comae Berenices*

R.A. 13^h 05^m 07^s Decl. +18° 03′

5.2 5.2 F5

1914.452	189°7	0″41	14^h1	3
.482	189.6	0.53	15.0	3
1918.528	192.1	0.39	15.8	3
1919.227	188.4	0.36	15.4	2
.421	191.4	0.37	14.1	3
1920.333	193.0	0.30	14.8	2
.371	192.7	0.26	15.1	2
1921.329	198.6	0.15	15.4	3
.357	190.9	0.13	15.2	2
.395	190.8	0.13	15.0	2

The comparison which follows is with positions computed from elements by Russell (*Publ. A.A.S.* **3**, 328, 1917):

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.47	189°6	0″47	−2°9	−0″02
1918.53	192.1	0.39	−0.4	+0.01
1919.32	189.9	0.36	−2.6	+0.04
1920.35	192.8	0.28	+0.3	+0.04
1921.36	193.4	0.14	+0.9	−0.01

6442 β 800

R.A. 13^h 11^m 51^s Decl. +17° 33′

6.6 10.0 K0

1919.432	111°0	3″90	15^h1	2
.459	110.0	3.98	14.6	2
1919.45	110°5	3″94	2n	

6468 Stone 29

R.A. 13^h 17^m 35^s Decl. +30° 50′

6.9 K0

1918.394 }
1921.357 } The star appeared round on both nights, and was also rated as single with the 12-inch in 1905. There are no measures except Stone's on one night in 1879. The star is probably not double.

6476 Ho 260

R.A. 13^h 18^m 56^s Decl. +29° 45′

9.4 9.7 K5

1918.079	339°6	0″67	11^h5	2
.394	341.7	0.67	17.1	2
1920.371	344.5	0.65	15.5	2
.410	346.0	0.61	15.0	2
1921.357	346.3	0.52	15.5	2
.395	347.8	0.65	15.8	2
.417	347.3	0.64	16.2	3

1918.24	340°6	0″67	2n
1920.39	345.2	0.63	2n
1921.39	347.1	0.60	3n

6524 OΣ 269

R.A. 13^h 28^m 20^s Decl. +35° 25′

7.3 7.8 A5

1914.504	228°7	0″29	15^h9	3
1919.268	228.5	0.23	15.8	2

6566 Σ 1768 25 *Can. Ven.*

R.A. 13^h 33^m 01^s Decl. +36° 48′

5.0 8.0 F0

1914.504	127°2	1″21	16.1	3

Jackson's orbit (*M.N.* **80**, 551, 1920) gives for this date 124°0, 1″29.

6578 β 612

R.A. 13^h 34^m 39^s Decl. +11° 15′

6.3 6.3 F2

1914.422	200°2	0″27	12^h9	2
.435	198.5	0.25	15.2	2
1916.303	203.1	0.29	13.2	3
.308	205.5	0.31	15.2	3
1918.378	214.6	0.26	15.3	2
.424	212.6	0.30	13.3	3
.444	210.7	0.29	14.4	2
1921.387	220.0	0.25	14.6	2
.395	226.4	0.28	15.5	2
.398	226.9	0.30	15.8	3

6578—(*Continued*)

Comparison with my ephemeris (*Publ. Lick Obs.* **12**, 86, 1912) gives the following residuals:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.43	199°.8	0″.26	+5°.5	−0″.02
1916.31	204.3	0.30	+1.3	−0.02
1918.42	212.6	0.28	+1.4	−0.06
1921.39	224.4	0.28	+1.8	−0.04

6663 β 614

R.A. 13^h 49^m 01^s Decl. +10° 38′

8.2 11.2 F0

1916.308	234°.5	0″.34	15^h.4	3
.316	235.4	0.32	15.9	3
1916.31	235°.0	0″.33	2n	

6711 β 1270

R.A. 13^h 58^m 46^s Decl. +8° 58′

8.5 8.6 F5

1914.435	206°.2	0″.15	15^h.5	2
.438	211.6	0.14	13.3	4
.504	225.5	0.13	16.3	3
1916.308	234.1	0.18	15.5	3
.316	236.0	0.17	16.2	3
1918.378	269.2	0.20	15.7	2
.424	267.6	0.19	13.6	3
.444	269.0	0.17	14.7	2
1919.421	273.0	0.22	14.6	3
.451	271.0	0.23	15.0	2
.470	265.8	0.22	15.7	3
1920.371	279.1	0.23	15.8	2
.511	277.1	0.22	16.1	2
1921.398	288.0	0.24	16.2	3
.417	284.7	0.21	16.7	3

The measures here recorded made it evident that the true period was considerably longer than the one given in my preliminary orbit (*Lick Obs. Publ.* **12**, 88, 1914), and that the other elements also required correction. Using Comstock's method (*A.J.* **31**, 33, 1918), for correcting an orbit differentially, I derived the following set of elements in 1920:

ELEMENTS

$P =$ 38.1 years
$T =$ 1911.58
$e =$ 0.41
$a =$ 0″.21
$\omega =$ 24°.4
$i =$ 20.5
$\Omega =$ 126.1
$n =$ +9°.449

EPHEMERIS

1923.40	297°.3	0″.26
1925.40	306.9	0.28
1927.40	315.7	0.29
1929.40	324.0	0.30
1931.40	332.3	0.29

MEASURES AND RESIDUALS

	θ_0	ρ_0			(O–C) $\Delta\theta$	$\Delta\rho$
1892.27	329°.7	0″.27	3n	β	+2°.5	−0″.02
1896.90	351.1	0.35	2	L	+3.0	+0.07
1898.44	342.8	0.44	2	Gr	−12.7	+0.17
1899.25	1.5	0.24	3	A	+1.7	−0.02
1900.27	6.8	0.24	4	A	+1.4	−0.01
1901.39	8.3	0.20	4	A	−3.9	−0.04
1.51	15.1	0.31	1	Bow	+2.1	+0.07
1903.40	23.1	0.17	2	Gr	−3.4	−0.04
3.42	25.9	0.15	1	A	−0.8	−0.06
1904.27	33.9	0.17	1	A	+0.1	−0.03
1905.30	45.8	0.15	2	A	+2.1	−0.04
1906.30	54.1	0.18	3	A	−0.6	+0.01
1907.38	62.0	0.18	2	A	−6.6	+0.02
1908.44	77.3	0.20	2	A	−6.9	+0.05
1911.49	147.4	0.16	2	A	+0.4	+0.04
1912.39	170.0	0.14	2	A	+1.6	+0.02
1914.46	214.4	0.14	3	A	+1.0	±0.00
1916.31	235.0	0.18	2	A	−7.4	+0.01
1918.42	268.6	0.19	3	A	+3.7	−0.01
1919.45	269.9	0.22	3	A	−3.3	±0.00
1920.44	278.1	0.22	2	A	−2.1	−0.01
1921.41	286.4	0.22	2	A	±0.0	−0.02

6764 OΣ 278

R.A. 14^h 08^m 18^s Decl. +44° 39′

8.3 8.6 F2

1916.267	65°.9	0″.28	17^h.3	3
1918.567	62.3	0.32	17.0	3

6832 Σ 1834

R.A. 14^h 16^m 38^s Decl. +48° 58′

8.0 8.1 F8

1914.575	85°.2	0″.20	17^h.5	3
.589	86.7	0.24	17.4	3
1916.267	87.9	0.27	17.5	3
.486	86.0	0.30	15.8	4
1920.401	89.3	0.38	17.6	3
1921.239	90.0	0.40	17.2	3
.335	86.6	0.47	16.7	2

The following residuals are derived from the orbit by Van den Bos (*Proc. Amsterdam Acad. Sci.* **24**, 72, 1921).

			(O−C) $\Delta\theta$	$\Delta\rho$
1914.58	86°.0	0″.22	+1°.4	+0″.07
1916.38	87.0	0.28	−3.0	+0.09
1920.40	89.3	0.38	−6.4	+0.08
1921.29	88.3	0.44	−8.2	+0.12

6842 β 1111

R.A. $14^h 18^m 28^s$ Decl. +8° 54′

7.4 7.4 A0

1914.435	120°7	0″17	15^h6	2
.438	130.2	0.15	13.5	3
.504	126.2	0.18	16.7	3
1916.308	166.9	0.19	16.1	3
.316	158.7	0.17	16.5	2
.486	172.1	0.15	15.2	4
1918.424	189.3	0.20	14.2	2
1919.421	206.8	0.16	15.1	2
.451	207.4	0.16	15.4	2
.470	208.1	0.17	15.9	3
1920.371	218.6	0.17	16.1	2
.511	222.2	0.17	16.5	2
1921.398	227.3	0.19	16.6	3
.417	229.4	0.19	17.4	3

A and BC = Σ 1835 5.1 6.6

1916.316	189.6	6.20	16.6	2

1914.46	125°7	0″17	3n
1916.37	165.9	0.17	3n
1918.42	189.3	0.20	1n
1919.45	207.4	0.16	3n
1920.44	220.4	0.17	2n
1921.41	228.4	0.19	2n

My orbit (*Lick Obs. Bull.* **8**, 99, 1914) includes the measures for 1914, but does not represent the later measures satisfactorily, the average residuals for the years 1919-1921 being (O–C) +20°6, −0″03.

6933 Hu 574

R.A. $14^h 30^m 49^s$ Decl. +19° 42′

9.1 9.4 K0

1920.262	108°1	0″31	15^h9	3
.333	106.2	0.30	15.7	3
1920.30	107°2	0″30	2n	

6955 Σ 1865 *ζ Bootis*

R.A. $14^h 36^m 22^s$ Decl. +14° 09′

4.5 4.9 A2

1914.613	319°9	0″77	17^h7	3
1916.470	318.3	0.80	14.6	2
.486	317.6	0.78	14.8	4
1919.451	319.5	0.82	15.8	2
.470	317.9	0.83	16.0	3
1921.354	317.7	0.86	16.1	2
.365	317.8	0.92	16.4	2

The difference in brightness of the components is that assigned by Struve; to my eye, the quadrant is indeterminate. The orbit has the remarkably large eccentricity 0.96, as determined independently by Hertzsprung and by me. The following comparison is with my orbit (*Publ. A.S.P.* **28**, 201, 1916).

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.61	319°9	0″77	−1°2	−0″08
1916.48	318.0	0.79	−2.4	−0.11
1919.46	318.7	0.82	−0.8	−0.15
1921.36	317.8	0.89	−1.1	−0.12

7001 OΣ 285

R.A. $14^h 41^m 44^s$ Decl. +42° 48′

7.8 8.2 F5

1921.395	87°5	0″48	16^h4	2
.398	86.1	0.44	17.4	2
1921.40	86°8	0″46	2n	

For this date, Jackson's elements (*M.N.* **80**, 553, 1920) give the position: 88°8, 0″48.

7013 Σ 1883

R.A. $14^h 43^m 56^s$ Decl. +6° 23′

7.5 7.5 F8

1916.524	222°3	0″32	15^h7	3
.544	222.4	0.30	16.3	3
1919.451	216.6	0.31	16.1	2
.470	215.9	0.32	16.2	3
1921.354	209.9	0.28	16.4	2
.365	213.1	0.26	17.2	2

1916.53	222°4	0″31	2n
1919.46	216.2	0.32	2n
1921.36	211.5	0.27	2n

This pair deserves careful attention during the next few years for the angular motion may become very rapid. The change in angle since Struve's first measures has been but 60°, but the distance has diminished from 1″24 to 0″27.

7034 Σ 1888 *ξ Bootis*

R.A. $14^h 46^m 46^s$ Decl. +19° 31′

4.8 6.8 G5, K4

1914.613	108°9	2″00	18^h0	3
1918.110	79.6	2.27	11.6	3
.433	76.5	2.07	17.9	3
1919.268	71.2	2.23	16.9	2
.361	74.7	2.29	15.3	2

The following comparison is with places computed from Doberck's elements (*A.N.* **214**, 89, 1921):

	θ_0	ρ_0	(O–C)$\Delta\theta$	$\Delta\rho$
1914.61	108°9	2″00	+0°3	−0″10
1918.27	78.0	2.17	−1.6	−0.08
1919.31	73.0	2.26	+0.5	−0.07

Voûte's elements (*A.N.* **212**, 483, 1920) do not represent the measures quite so well.

7214 Σ 1932

R.A. $15^h 14^m 04^s$ Decl. +27° 12′

7.3 7.3 F8

1918.433	10°7	0″54	18^h1	3
1919.418	11.5	0.59	17.4	3
1921.398	17.0	0.59	17.6	2
.417	16.3	0.60	17.8	3

1918.93	11°1	0″56	2n
1921.41	16.6	0.60	2n

7251 Σ 1937 η *Cor. Bor.*

R.A. $15^{h}\ 19^{m}\ 04^{s}$ Decl. +30° 39′

5.6 6.1 G0

1918.392	74°4	0″57	$13^{h}1$	2
.394	73.3	0.64	18.4	3
.433	72.8	0.57	18.3	3
1918.41	73°5	0″59	3n	

The residuals from Lohse's ephemeris (*Potsdam Obs. Publ.* **20**, 119, 1908) are: (O–C) −2°3, −0″07.

7332 OΣ 298

R.A. $15^{h}\ 32^{m}\ 30^{s}$ Decl. +40° 08′

7.3 7.6 K0

1918.583	203°0	0″90	$18^{h}4$	3
1926.377	204.7	0.74	17.6	3
.401	206.0	0.76	18.2	3
1920.39	205.4	0.75	2n	

Comparison with Celoria's orbit (*A.N.* **119**, 163, 1888) gives residuals (O–C) of +3°4 and +2°8 in angle, but −0″20 and −0″27 in distance.

7360 Hu 580 ι *Serpentis*

R.A. $15^{h}\ 37^{m}\ 06^{s}$ Decl. +19° 59′

5.2 5.2 A2

1915.632	66°0	0″19	$17^{h}9$	3
1918.433	60.2	0.14	18.7	3
.641	86.±	0.10±	17.9	3

1919. } Elongation too slight for even approximate meas-
1920. } ures. 3n

1921.365	220°7	0″12	$17^{h}8$	2
.587	240.6	0.12	17.3	3
.609	235.6	0.10	17.1	3
1921.52	232°3	0″11	3n	

The measures in 1918 are obviously uncertain and the first measure in 1921 probably deserves small weight because of poor seeing. The companion is placed in the third quadrant on the assumption that the arc it has traversed since discovery exceeds 100°. The elongation in 1921 was noted as "certain" on all three nights.

7368 Σ 1967 γ *Cor. Bor.*

R.A. $15^{h}\ 38^{m}\ 33^{s}$ Decl. +26° 37′

4.0 7.0 A0

1915.632	113°5	0″70	$18^{h}1$	3
1920.401	114.1	0.68	17.9	2
.596	113.7	0.56	17.4	3
1920.50	113°9	0″62	2n	

Lewis's elements (*Mem. R.A.S.* **56**, 429, 1906) give for the epoch 1920.50, the position 109°0, 0″61.

7375 Σ 1969

R.A. $15^{h}\ 39^{m}\ 24^{s}$ Decl. +60° 18′

8.9 9.6 K0

1915.632	57°1	0″55	$18^{h}3$	3
1920.607	62.7	0.42	18.4	3
.670	60.6	0.52	19.2	3
1920.64	61°6	0″46	2n	

7416 Σ 1989 π^{2} *Ursae Min.*

R.A. $15^{h}\ 45^{m}\ 06^{s}$ Decl. +80° 17′

7.4 8.2 F2

1914.589	64°9	0″24	$18^{h}2$	3
.613	65.1	0.21	18.3	3
.652	64.4	0.26	18.3	3
1915.550	62.2	0.26	17.2	4
.632	61.9	0.30	18.7	3
1920.607	58.1	0.41	18.7	2
.670	57.0	0.35	18.9	4

My orbit (*Publ. Lick Obs.* **12**, 100, 1914) does not represent the observed position angles satisfactorily.

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.62	64°8	0″24	+13°4	−0″01
1915.59	62.0	0.28	+12.8	±0.00
1920.64	57.6	0.38	+15.7	±0.00

7487 Σ 1998 ξ *Scorpii*

R.A. $15^{h}\ 58^{m}\ 52^{s}$ Decl. −11° 06′

4.8 5.1 F8

1914.435	163°7	0″68	$15^{h}9$	2
.575	168.5	0.70	16.9	3
1916.524	169.9	0.72	15.9	3
.544	170.7	0.82	16.0	3
1918.501	174.5	0.91	16.6	3
.600	175.4	0.92	17.1	3
1921.436	177.6	0.98	16.4	2
.439	178.0	1.06	15.4	2
.507	177.4	1.00	15.4	3

AB and C —— 7.2 ——

1921.507	56°2	7″96	15.5	3

The residuals for my measures of the close pair derived by comparison with my ephemeris (*Publ. Lick Obs.* **12**, 103, 1912), follow:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.50	166°1	0″69	−0°5	−0″18
1916.53	170.3	0.76	−2.0	−0.21
1918.55	175.0	0.92	−1.8	−0.14
1921.46	177.7	1.01	−4.8	−0.15

7506 β 949

R.A. $16^{h}\ 02^{m}\ 59^{s}$ Decl. −9° 50′

7.3 7.4 F8

1914.435	186°5	0″16	$16^{h}1$	2
.575	189.4	0.16	17.1	3
1915.432	184.6	0.24	15.5	3
.446	181.6	0.24	15.3	3
1916.524	191.1	0.23	16.1	3
.644	190.9	0.24	16.1	3
1918.501	187.4	0.29	16.8	3
.600	190.3	0.28	17.4	2
1920.338	188.9	0.32	16.0	3
.377	186.9	0.32	16.8	2
1921.436	186.7	0.32	16.7	2
.439	187.7	0.37	15.6	2
.570	186.5	0.36	15.7	3

7506—*Continued*

1914.57	188°2	0″16	2n
1915.44	183.1	0.24	2n
1916.58	191.0	0.24	2n
1918.56	188.8	0.28	2n
1920.36	187.9	0.32	2n
1921.48	187.0	0.35	3n

The apparent change is almost entirely in the distance, the extreme range in observed position angle, since discovery in 1880, being only 20°. In the years 1902 to 1911 the pair was at or near the limit of the resolving power of the 36-inch telescope, but it is not yet certain whether there were two conjunctions or only one in that interval. In 1921 the south component appeared to be slightly fainter than the northern one, and the difference in magnitude given is based on the estimates in that year.

J.C. 2414 Σ 2028 (rej)

R.A. 16ʰ 09ᵐ 21ˢ Decl. +39° 36′

8.7 9.2 G0

1921.327	150°7	0″55	18ʰ0	2
.398	150.7	0.45	17.9	2
1921.36	150°7	0″50	2n	

The only earlier measures are my own in 1906 and 1912. There is little evidence of motion in the 15 years' interval.

7561 Σ 2026

R.A. 16ʰ 11ᵐ 34ˢ Decl. +7° 37′

9.1 9.6 K5

1914.419	104°1	0″54	14ʰ9	3
.455	107.0	0.48	18.1	3
1916.316	94.3	0.51	17.9	2
.505	90.4	0.48	15.3	3
1919.470	70.3	0.64	17.8	3
1920.377	70.3	0.66	17.0	2
.401	67.8	0.63	18.9	3

The latest orbit is by Comstock (*A.J.* **31**, 33, 1918). Comparison with places computed from it gives the following residuals:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.44	105°6	0″51	−2°8	+0″07
1916.41	92.4	0.50	−2.2	−0.01
1919.47	70.3	0.64	−2.7	+0.03
1920.39	69.0	0.64	+0.7	−0.01

7636 HΣ — = Hu 483

R.A. 16ʰ 23ᵐ 26ˢ Decl. +21° 07′

8.3 13.0 G

1922.622	299°9	1″65	18ʰ3	3

A and C = OΣ 311 —— 11.0

1922.622	224°9	4″83	18ʰ5	3

The close pair has shown no change since its discovery by Hermann Struve in 1887. The change in the wide pair is due to proper motion.

7642 Σ 2052

R.A. 16ʰ 24ᵐ 30ˢ Decl. +18° 37′

7.8 7.8 K0

1918.641	5°5	0″25	18ʰ9	3
.649	6.3	0.25	19.6	2
1920.596	303.4	0.34	17.8	3
.607	302.2	0.31	17.9	3
1921.439	289.5	0.37	14.6	2

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1918.64	5°9	0″25	+15°9	+0″07
1920.60	302.8	0.32	+5.4	−0.04
1921.44	289.5	0.37	−4.1	−0.08

The only orbit for this pair is by Jackson (*M.N.* **80**, 741, 1920). The residuals given above imply that the motion about the date of periastron (1920-21) was not so rapid and the minimum angular separation not quite so small as this orbit gives them.

7651 Σ 3105

R.A. 16ʰ 26ᵐ 26ˢ Decl. −6° 48′

8.7 8.7 A0

1915.432	21°2	0″46	16ʰ0	3
1921.354	19.8	0.36	17.6	2
.507	18.0	0.33	15.9	3
1921.43	18°9	0″34	2n	

7726 β 953

R.A. 16ʰ 37ᵐ 14ˢ Decl. +69° 59′

8.6 9.1 F5

1914.589	158°0	0″20	18ʰ6	3
.613	151.9	0.19	18.6	3
.652	160.5	0.21	19.4	3
1915.542	157.0	0.19	19.2	3
.550	156.4	0.24	17.7	4
1920.607	149.5	0.28	18.9	3
.670	148.2	0.30	19.4	4

1914.62	156°8	0″20	3n
1915.55	156.7	0.22	2n
1920.64	148.8	0.29	2n

7717 Σ 2084 *ζ Herculis*

R.A. 16ʰ 37ᵐ 31ˢ Decl. +31° 47′

3.0 6.0 G0

1914.419	115°1	1″51	13ʰ5	3
.438	114.6	1.29	13.6	3
.589	117.0	1.32	19.1	3
1916.366	105.1	1.45	14.5	3
1917.639	98.0	1.50	19.1	3
.694	97.6	1.35	19.9	3
1919.418	89.6	1.37	19.2	3
1920.596	83.4	1.38	18.5	3
.601	84.9	1.39	19.4	3
1921.587	80.0	1.34	17.7	3
.609	78.7	1.35	17.8	3

7717—(*Continued*)

The constant difference of about 2° between my observed angles and those given by Comstock's ephemeris (A.J. **30**, 139, 1917) may be due to systematic error of measure; but the increasing residuals in distance would seem to require a different explanation.

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.48	115°8	1″37	−2°0	−0″02
1916.37	105.1	1.45	−2.0	−0.02
1917.67	97.8	1.43	−2.5	−0.08
1919.42	89.6	1.37	−2.3	−0.19
1920.60	84.2	1.39	−2.2	−0.19
1921.60	79.4	1.35	−2.4	−0.24

7748 Δ 15

R.A. $16^h\ 40^m\ 50^s$ Decl. +43° 40′

8.9 9.1 K5

1914.419	253°9	0″48	13^h7	3
.589	259.7	0.40	18.8	3
1916.385	249.8	0.47	14.0	3
1917.756	244.5	0.47	20.1	2
1920.377	229.7	0.55	18.2	2
.582	227.7	0.44	19.6	2
1921.327	225.8	0.50	18.5	2

The residuals from Jackson's ephemeris (*M.N.* **80**, 556, 1920) follow:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.50	256°8	0″44	−7°9	−0″04
1916.38	249.8	0.47	−7.1	−0.02
1917.76	244.5	0.47	−4.3	−0.03
1920.48	228.7	0.50	−7.5	−0.01
1921.33	225.8	0.50	−6.7	−0.02

7778 Σ 2106

R.A. $16^h\ 46^m\ 22^s$ Decl. +9° 25′

7.0 8.7 F8

1914.504	281°3	0″23	18^h2	2
.575	285.3	0.27	18.5	3
1916.308	277.2	0.25	17.6	3
.505	281.5	0.21	15.7	3
1919.470	268.3	0.24	18.0	3
1920.371	271.1	0.21	17.6	2
.505	267.7	0.22	18.2	2
.511	263.9	0.28	17.4	2

1914.54	283°3	0″25	2n
1916.41	279.4	0.23	2n
1919.47	268.3	0.24	1n
1920.46	267.6	0.24	2n

7783 Σ 2107

R.A. $16^h\ 47^m\ 53^s$ Decl. +28° 50′

6.8 8.3 F5

1914.419	22°1	0″70	14^h2	3
.589	20.5	0.58	19.6	3
1916.366	31.3	0.69	14.9	2
1917.639	24.8	0.60	19.2	3
1920.596	31.5	0.59	18.3	3
.607	31.0	0.63	19.5	2

Jackson's elements (*M.N.* **80**, 557, 1920) differ widely from Rabe's (*A.N.* **198**, 116, 1914) but the observations to date are not sufficient to decide which is the better approximation. The residuals which follow are from Jackson's ephemeris.

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.50	21°3	0″64	−1°4	+0″07
1917.00	28.0	0.64	−3.3	+0.04
1920.60	31.2	0.61	−11.0	±0.00

7823 β 1298

R.A. $16^h\ 54^m\ 46^s$ Decl. +9° 50′

8.5 9.0 F0

1920.505	100°0	0″34	18^h4	2
.511	101.3	0.35	17.7	2
1920.51	100°6	0″34	2n	

The apparent motion, so far, has been very slow.

7834 Σ 2118 20 *Draconis*

R.A. $16^h\ 55^m\ 55^s$ Decl. +65° 11′

7.0 7.5 F0

1915.632	80°1	0″51	19^h1	3

13364 Hu 1176 c *Herculis*

R.A. $17^h\ 04^m\ 29^s$ Decl. +36° 04′

6.1 6.1 A5

1914.419	272°3	0″15	14^h5	3
.613	260.2	0.15	19.4	3
1918.433	Too close		19.0	3
1919.418	135.1	0.13	19.5	3
1921.518	101.5	0.15	15.9	3
.532	100.7	0.14	15.8	3

This close pair has completed a full revolution since its discovery by Hussey in 1905. The maximum observed separation is only 0″17 and, at minimum, the pair cannot be resolved with the 36-inch. I have utilized the few available measures in an attempt to compute an approximate orbit by graphical methods. The results, which follow, will doubtless require radical changes when further observations have been made, but they will serve to give an idea of the character of the motion. The revolution period is probably substantially correct.

Elements

$P =$ 15.5 years
$T =$ 1919.9
$e =$ 0.14
$a =$ 0″16
$\omega =$ 308°4
$i =$ 56.0
$\Omega =$ 90.8
$n = -23°226$

Ephemeris

1923.5	58°9	0″13
1924.5	34.3	0.11
1925.5	1.7	0.10
1926.5	330.8	0.11
1927.5	309.2	0.13
1928.5	292.8	0.16

13364—(*Continued*)

MEASURES AND RESIDUALS

	θ_0	ρ_0			(O–C) $\Delta\theta$°	$\Delta\theta$″	$\Delta\rho$
1905.32	111°8	0″12	2n	Hu	+7°5	+0″02	−0″01
1906.33	90.4	0.14	3	A	+3.0	+ .01	±0.00
1907.63	65.2	0.12	2	A	−0.9	−0.00	−0.01
1911.59	319.4	0.13	4	Bry	+2.8	+0.01	+0.01
1912.58	294.7	0.17	3	A	−4.4	−0.01	+0.02
12.69	290.0	0.16	3	Bry	−7.5	−0.02	+0.01
1913.65	266.3	0.13	1	Bow	(−19.0)	−0.06	−0.04
1914.53	266.2	0.15	2	A	−9.2	−0.03	−0.02
1918.43	Too close		1	A	——		——
1919.42	135.1	0.13	1	A	−7.8	−0.01	+0.04
1921.52	101.1	0.14	2	A	+8.8	+0.02	±0.00

The computed distance for the date 1918.43 is 0″08. It will be seen that, except for the single night's measure by Bowyer, in 1913, the residuals are not greater than those that may be expected in so close a pair. The angle residuals, however, show a systematic run.

7885 β 1118 *η Ophiuchi*

R.A. $17^h\,04^m\,38^s$ Decl. −15° 36′

3.1 3.6 A2

1918.501	239°6	0″63	17^h0	3
1921.507	238.0	0.60	16.6	3

13367 Hu 1178

R.A. $17^h\,08^m\,15^s$ Decl. +39° 23′

8.8 8.9 F8

1921.707	184°8	0″28	19^h5	3
.729	185.5	0.30	19.9	3
1921.72	185°2	0″29	2n	

C and D 9.2 13.0

1921.729	77°2	1″12	20.0	3

AB and C = Σ 2136

1921.729	113°8	15″41	20.2	3

Hussey records the quadrant of the close pair as north, with a difference of 0.3 magnitudes in the brightness of the components:

7936 OΣ 327

R.A. $17^h\,12^m\,15^s$ Decl. +56° 15′

8.5 8.7 F2

1918.567	333°2	0″46	19^h4	2
.583	328.0	0.47	19.2	3
1920.582	334.8	0.47	19.9	2
.607	329.9	0.40	19.2	2

1918.58	330°6	0″46	2n
1920.59	332.4	0.44	2n

Change in this pair since its discovery in 1846 is doubtful.

8038 Σ 2173

R.A. $17^h\,25^m\,15^s$ Decl. −0° 59′

5.9 6.2 G5

1914.435	160°5	0″45	16^h5	3
.449	159.5	0.49	17.4	3
1915.503	158.5	0.58	17.4	3
.604	158.7	0.54	17.9	3
1918.600	151°4	0″74	17^h7	2
1919.457	150.3	0.75	18.1	2
1921.354	146.8	0.76	17.8	2
.365	147.8	0.75	18.3	2

My elements (*Publ. Lick Obs.* **12**, 116, 1912) continue to represent the observed position angles fairly well but the residuals in distance are not so satisfactory.

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.44	160°0	0″47	−3°3	−0″14
1915.55	158.6	0.56	−1.2	−0.17
1918.60	151.4	0.74	−1.9	−0.16
1919.46	150.3	0.75	−1.7	−0.17
1921.36	147.3	0.76	−0.7	−0.06

8099 β 962

R.A. $17^h\,33^m\,57^s$ Decl. +61° 57′

5.3 10.0 F8

1914.613	337°5	1″44	18^h8	3
.652	337.7	1.49	18.7	3
1920.582	334.7	1.65	20.4	2
.596	334.6	1.68	20.5	3

			(O–C) $\Delta\theta$	$\Delta\rho$
1914.63	337°6	1″46	+0°7	−0″05
1920.59	334.6	1.66	−3.7	+0.10

Russell gives two orbits (*Publ. A.A.S.* **3**, 329, 1917), with periods, respectively, of 111 years and 77.8. The former, which leads to smaller residuals, especially for the observed distances, has been used in the above comparison.

8162 A.C. 7 *μ′ Herculis*

R.A. $17^h\,42^m\,33^s$ Decl. +27° 47′

10.0 10.5 Mb

1914.583	155°7	0″50	19^h3	3
.589	152.3	0.58	19.8	3
1915.542	174.6	0.57	18.9	4
.618	173.5	0.55	19.2	3
1916.576	190.5	0.56	19.3	2
.722	197.8	0.54	19.8	3
1917.584	204.4	0.62	20.1	3
1918.433	213.6	0.66	19.3	3
.649	215.0	0.74	20.1	4
1919.418	221.4	0.81	20.2	3
.476	222.6	0.82	19.9	3
1920.401	227.9	0.92	20.0	2
.596	229.3	0.78	19.7	3
.601	228.9	0.77	20.3	3
1921.436	233.5	1.02	15.5	2
.439	234.8	1.00	15.1	2

Comparison with my ephemeris (*Lick Obs. Publ.* **12**, 119, 1914) follows:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.59	154°0	0″54	+13°6	−0″04
1915.58	174.0	0.56	+14.5	±0.00
1916.65	194.2	0.55	+14.6	−0.05
1917.58	204.4	0.62	+10.4	−0.04
1918.54	214.3	0.70	+8.1	−0.04
1919.45	222.0	0.82	+6.8	−0.02
1920.53	228.7	0.82	+5.0	−0.11
1921.44	234.2	1.01	+4.4	+0.02

There are very few earlier measures of the companion in the part of the orbit traversed in the years 1914 to 1920.

8340 Σ 2272 70 *Ophiuchi*

R.A. 18$^{\text{h}}$ 00$^{\text{m}}$ 24$^{\text{s}}$ Decl. +2° 31′

4.1 6.1 K0, K4

1914.455	141°0	4″42	18$^{\text{h}}$8	3
.485	141.1	4.12	19.3	3
.641	142.1	4.39	20.3	3
1918.493	135.4	5.33	18.0	2
.600	135.1	5.47	18.8	2

The latest investigation of this well known system is by Pavel (*A.N.* **212**, 347, 1921). Comparison with positions computed from his definitive elements gives the following representation of my measures:

	θ_0	ρ_0	(O–C) Δθ	Δρ
1914.53	141°4	4″31	−1°1	−0″11
1918.55	135.2	5.40	−0.7	+0.18

8353 OΣ 341

R.A. 18$^{\text{h}}$ 01$^{\text{m}}$ 35$^{\text{s}}$ Decl. +21° 26′

7.3 8.2 G0

1914.583	96°7	0″31	19$^{\text{h}}$5	3
.589	95.8	0.37	19.9	3
1916.576	95.2	0.22	19.8	3
.585	98.9	0.23	19.9	3
.653	96.7	0.26	19.7	3
1917.584	86.5	0.15	20.5	3
1918.446	76.0	0.11	16.1	3
1919.418	79.9	0.16	20.4	3
.476	82.8	0.22	20.2	3
1920.333	89.6	0.30	17.0	3
.338	92.4	0.27	16.5	3
1921.425	89.4	0.31	15.8	3
.436	89.3	0.36	16.0	2

This pair, long assumed to be apparently fixed, with an angular separation of approximately 0″4, was found by Hussey and, later by me to be too close for resolution with the 36-inch refractor early in the year 1898. Late that year Hussey was able to measure it, and in 1899 it was not very difficult. The distance increased to a maximum of about 0″5 in the years 1908-1910 and then again diminished until, in 1917-1918, it was really too close to measure. My distance measures in those years give the diameter of the elongated image rather than the distances between the centers of the two star disks. In 1919, it was again readily measurable and, since the difference in the brightness of the two components is sufficient to establish the quadrant with certainty, it was seen that the companion was again in the position it held in 1899.

A plot of the measures made here in that interval showed that the period must be approximately 20 years, the inclination of the orbit plane very high and the eccentricity greater than that of any other known visual binary. By considering also the earlier measures a preliminary set of elements was derived by graphical methods and these were varied until the following results were obtained. They are to be regarded as first approximations. The pair will be within the resolving power of telescopes of moderate aperture until about 1935 and measures made in this interval, and particularly covering the maximum elongation in 1925-1931, will afford the data for a good orbit. Good distance measures are especially desirable.

Taking the mass of the system as 1.7 times that of the Sun, these elements give +0″034 for the hypothetical parallax; there are no published values for the spectroscopic or trigonometric parallax. The absolute magnitudes of the components are found to be +5.0 and +5.9.

ELEMENTS

$P =$ 19.75 years
$T =$ 1917.85
$e =$ 0.96
$a =$ 0″30
$\omega =$ 149°0
$i =$ 77.5
$\Omega^* =$ 98.0
$\hbar =$ +18.2275

* This was erroneously given as 104°0 in *Publ. A.S.P.* **32**, 220, 1920.

EPHEMERIS

1923.60	88°8	0″42
25.60	89.7	0.48
27.60	90.5	0.51
29.60	91.3	0.51
31.60	92.1	0.48
33.60	93.1	0.41
35.60	94.6	0.31
37.60	270.6	0.01
39.60	110.4	0.23

MEASURES AND RESIDUALS

					(O–C)	
	θ_0	ρ_0			Δθ	Δρ
1843.34	94°0	0″34	2n	Ma	+6°0	−0″03
1846.09	90.8	0.50	3	OΣ	+1.3	+0.03
1852.27	92.7	0.50	3	OΣ	+0.7	+0.02
1865.16	89.0	Cun	2	Dem	−0.2	....
1868.66	83.5	Sep.	1	Dem	−7.1	....
1872.61	90.7	Elong	3	Dem	−1.5	....
1877.56	Not seen		1	OΣ		
(77.62	86.9	0.4±	2	Sp)	(−10.2	+0.24±
(1879.59	78.1	0.35±	1	Sp)	(−4.5	+0.20±)
1882.54	87.6	0.40	2	OΣ,HΣ	−0.1	+0.05
1883.64	91.4	0.40	3	Per	+2.9	−0.01
3.70	82.3	0.49	1	OΣ	−6.2	+0.08
1884.55	91.2	0.45	3	Per	+2.2	+0.01
1885.74	83.2	0.51	2	Eng	−6.3	+0.04
1886.65	87.7	0.53	5	Eng	+2.2	+0.05
1898.32	No elongation		5	Hu,A		
1898.75	74.0	0.10	3	Hu	−4.0	+0.02
1899.61	86.2	0.18	4	Hu	+2.5	+0.01
1900.46	92.4	0.26	3	Hu	+6.7	+0.01
.62	84.6	0.24	3	A	−1.3	−0.01
1901.4	86.1	0.30	9	Gr	−0.8	−0.01
1.51	93.6	0.33	2	Hu	+6.6	+0.02
1902.47	89.6	0.35	3	Hu	+1.7	−0.01
1903.63	90.6	0.42	3	Com	+1.9	±0.00
1905.41	91.0	0.40	1	A	+1.5	−0.07
5.44	95.4	0.40	1	Lau	+5.9	−0.07
5.52	91.9	0.43	1	v. Bies	+2.3	−0.04
5.9	90.5	0.38	9	Gr	+0.7	−0.10
1906.56	92.6	0.51	3	Com	+2.6	+0.02

8353—(*Continued*)

	θ_0	ρ_0			(O–C) $\Delta\theta$	$\Delta\rho$
1907.62	87°2	0″52	2	Com	−3°2	+0″01
7.62	93.2	0.62	4.3	Prz	+2.8	+0.11
1908.52	87.9	0.48	4	Doo	−2.6	−0.03
8.61	94.5	0.49	3	v. Bies	+3.9	−0.02
1909.54	86.8	0.46	3	J	−4.6	−0.05
9.64	92.5	0.52	3	Com	+1.3	+0.01
1910.27	93.2	0.48	1	A	+1.8	−0.03
10.67	92.8	0.45	4	Fox	+1.3	−0.05
1913.2	92.8	0.34	14	Gr	±0.0	−0.09
1914.55	97.8	0.44	3	Com	+4.2	+0.06
14.59	96.2	0.34	2	A	+2.6	−0.04
1915.60	92.7	0.36	2	Com	−1.7	+0.04
1916.60	96.9	0.24	3	A	+1.2	+0.01
16.62	101.0	0.27	3	Com	+5.2	+0.04
1917.58	86.5	0.15	1	A	−13.9	+0.07
(17.60	137.	0.30	2	Com)*	(+50±	+0.22±)
1918.44	76.0	0.11	1	A	−3.0	+0.04
(18.59	129.0	0.42	2	Com)*	(+50±	+0.3±)
1919.45	81.4	0.19	2	A	−2.6	+0.01
19.6	85.0	0.28	2	Gr	+0.6	+0.09
1920.34	91.0	0.28	2	A	+5.1	+0.03
1921.43	89.4	0.34	2	A	+2.2	+0.02

* Comstock's notes show that he regarded these observations as very uncertain. On other nights in these years and in 1919 he was unable to see the companion.

8372 A.C. 15 99 *Herculis*

R.A. $18^h\,03^m\,14^s$ Decl. +30° 33′

5.2 10.5 F8

1914.613	343°7	1″46	19^h8	3
.616	342.7	1.44	22.1	4
1918.641	348.1	1.49	20.3	2
.649	349.6	1.51	20.4	3
1921.436	355.5	1.65	15.8	2
.655	351.6	1.45	20.7	3

Lohse's orbit (*Publ. Potsdam Obs.* **20**, 158, 1908) represents these measures as follows:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.61	343°2	1″45	−6°5	−0″09
1918.64	348.9	1.50	−8.0	−0.02
1921.55	353.6	1.55	−8.7	+0.06

8380 Σ 2281 73 *Ophiuchi*

R.A. $18^h\,04^m\,36^s$ Decl. +3° 59′

5.9 7.4 F2

1914.455	81°2	0″40	19^h0	2
.485	79.0	0.39	19.5	3
1916.576	77.0	0.50	18.6	2
1918.493	73.9	0.44	18.2	2
.600	73.9	0.54	19.1	3
1921.365	74.8	0.54	18.8	2
.425	71.5	0.59	16.1	2
.436	72.3	0.64	17.0	2

The observations to date do not suffice to decide whether Russell's orbit (*Publ. A.A.S.* **3**, 329, 1917) with a period of 220, or Jackson's (*Green. Cat.* of *Double Stars*, p. 223, 1922) with a period of 423.5 years is the better one. This will appear from the following comparison:

			(O–C) Russell		(O–C) Jackson)	
	θ_0	ρ_0	$\Delta\theta$	$\Delta\rho$	$\Delta\theta$	$\Delta\rho$
1914.47	80°1	0″40	−1.2	−0″01	−1°2	+0″03
1016.58	77.0	0.50	−0.7	+0.04	−0.1	+0.08
1918.55	73.9	0.49	−1.0	±0.00	−0.3	+0.02
1921.41	72.9	0.59	+2.1	+0.08	+2.7	+0.07

The ratios $a^3 \div p^2$, differ by but 0.00001, so that the two orbits give substantially identical values for the hypothetical parallax, as Jackson has remarked.

8433 Σ 2294

R.A. $18^h\,09^m\,27^s$ Decl. +0° 09′

8.5 8.6 F2

1916.316	100°5	0″56	18^h2	2
1918.600	98.6	0.54	19.3	2
1921.354	99.9	0.51	18.2	2
.365	100.5	0.54	18.6	2
1919.41	99°9	0″54	4n	

8467 β 639

R.A. $18^h\,12^m\,51^s$ Decl. −18° 39′

6.5 8.5 B0

1916.722	151°6	0″39	19^h1	3
1919.457	148.2	0.43	18.6	2
.470	146.0	0.46	18.6	2
1921.609	147.3	0.47	19.2	3
.661	151.6	0.53	18.9	3
1919.78	148°9	0″46	5n	

8535 A.C. 11

R.A. $18^h\,19^m\,46^s$ Decl. −1° 38′

6.8 6.8 F5

1914.455	7°7	0″25	19^h2	3
.485	7.7	0.25	19.7	3
1915.503	4.5	0.24	18.2	3
1919.457	0.5	0.32	18.8	2
.470	0.8	0.30	18.3	3
1921.354	356.7	0.36	18.7	2
.422	358.6	0.36	18.6	2

1914.87	7°7	0″25	2n
1915.50	4.5	0.24	1n
1919.46	0.6	0.31	2n
1921.39	357.6	0.36	2n

In 1854 the position angle of this pair was 178°0 and the distance 0″4± according to two measures by Dawes. There are few later measures before my own began (none in the interval 1889-1905) and these do not give any certain evidence of orbital motion. In 1905, however, I found the pair at, or below, the limit of resolving power of the 36-inch. The angular separation

8535—(*Continued*)

has increased steadily since then, with relatively little change in the position angle. The orbit plane evidently has a high inclination, but since the two components are of equal brightness, it is not yet possible to assign even an approximate value to the period or to say whether the orbit is nearly circular or very eccentric. The only published measures since 1889, except my own, are those by Leavenworth on two nights, 1916.52, 180°0, 0″28.

8543 β 1203

R.A. 18^h 20^m 58^s Decl. +0° 44′

7.6 7.8 A3

1914.455	89°2	0″34	19^{h}4	3
.485	85.1	0.26	19.8	3
1921.661	96.2	0.31	19.8	3
.707	92.8	0.33	19.2	3
1914.47	87°2	0″30	2n	
1921.68	94.5	0.32	2n	

8578 OΣ 353 *φ Draconis*

R.A. 18^h 22^m 12^s Decl. +71° 17′

4.4 6.1 A0p

1915.522	31°6	0″30	17^{h}4	3
1920.670	32.2	0.21	20.7	3
1921.579	29.8	0.25	20.8	3
.661	35.0	0.28	21.5	2
1921.62	32°4	0″26	2n	

In 1906, Burnham wrote, "No sensible change in the last fifty years;" but in the 15 years since then there has been a marked change in the angle with diminishing angular separation.

8662 OΣ 359

R.A. 18^h 31^m 21^s Decl. +23° 31′

6.4 6.7 K0

1914.641	144°9	0″19	21^{h}0	3
.653	143.5	0.21	19.6	3
1916.576	135.7	0.19	20.1	3
.585	137.4	0.17	20.3	3
.653	141.2	0.15	19.9	3
1918.433	134.5	0.14	20.0	3
1920.338	110.2	0.12	16.8	3
.596	87.6	0.14	21.2	3
.601	95.9	0.13	21.5	2
1921.650	93.8	0.12	20.9	3
.655	95.9	0.12	20.9	3
1914.65	144°2	0″20	2n	
1916.60	138.1	0.17	3n	
1918.43	134.5	0.14	1n	
1920.51	97.9	0.13	3n	
1921.65	94.8	0.12	2n	

This is another pair in which the apparent motion for half a century after discovery was very slow, the distance diminishing from 0″66 in 1849 to 0″38 in 1903, and the angle decreasing only 13°. It is now an extremely close pair, and the quadrant is quite indeterminate, but there is no question but that the direction of elongation is correctly given.

8687 Hu 198

R.A. 18^h 33^m 34^s Decl. +8° 45′

Var. Md.

1922.660	348°4	0″25	19^{h}5	2
.718	353.5	0.29	19.2	3
1922.69	351°0	0″27	2n	

This star was known to be variable before Hussey discovered it to be double. As a variable it is catalogued as X *Ophiuchi*, period 335 days,[1] magnitude at maximum 6.5; at minimum, 9.0. Van Biesbroeck's observations, confirmed by Gingrich's investigation[2], shows that the north component of the pair is the variable. Hussey, in 1900.47, found 195°2, 0″22; Van Biesbroeck, 1920.67, found 171°1, 0″22. At the time my measures were made the north component seemed to be about 0.6 magnitude fainter than the southern one. This agrees well with the conclusion just stated, for the variable should have been at minimum brightness about September 2 (1922.671). The observed change of quadrant is therefore due to the variability of the north component, not to the orbital motion.

8736 Σ 2367

R.A. 18^h 37^m 26^s Decl. +30° 12′

7.4 7.9 G5

1914.485	75°3	0″34	20^{h}5	2
.641	74.8	0.34	21.3	3
1918.649	70.7	0.44	20.7	3
.756	73.5	0.34	20.8	3
1914.56	75°0	0″34	2n	
1918.70	72.1	0.39	2n	

8849 β 971

R.A. 18^h 44^m 55^s Decl. +49° 19′

7.2 F5-A

1917.617	205°7(?)	0″14(?)	22^{h}2	4

The object measured as the companion star seemed to be a real star, but the measures were extremely difficult. On four other good nights in 1914, 1919 and 1921, no trace of the companion could be found. In fact, the result in 1917 is the only positive one I have obtained since 1905 (see *Publ. Lick Obs.* **12**, 131, 1914). It is an interesting fact that Miss Cannon finds the spectrum composite, the two spectra being of nearly equal intensity. Burnham, in 1879, estimated the magnitudes as 6.5, 8.5.

8933 β 648

R.A. 18^h 53^m 17^s Decl. +32° 46′

5.3 8.8 G0

1914.485	67°1	0″68	20^{h}7	3
.488	69.2	0.67	16.8	3
1916.524	55.8	....	16.8	2
.733	56.0	0.80	21.0	3
.798	57.7	0.79	20.5	4
1918.641	49.6	0.95	20.6	3
.649	48.8	0.95	21.1	3
1919.476	47.9	1.04	20.9	3

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[1] 337 days, from maximum 1920, June 2 to maximum May 5, 1921.

[2] *Ap. Jour.*, **56**, 132, 1922. Van Biesbroeck's results are here quoted by Gingrich.

8933—(*Continued*)

1920.333	43°.9	1″.30	$17^h.3$	3
.338	49.8	1.17	17.1	3
.596	42.7	1.10	21.5	2
.601	45.4	1.08	21.7	3
1921.737	38.9	1.19	20.4	2
.751	40.9	1.01	22.5	3
.830	39.2	1.02	20.7	4

Van den Bos has an orbit, computed in 1922 (*B.A.N.* **12**, 57), which represents my observed positions better than does my own orbit, computed in 1912. Further revision will be desirable, after a full revolution has been observed.

			(O–C) Aitken		Van den Bos	
	θ_0	ρ_0	$\Delta\theta$	$\Delta\rho$	$\Delta\theta$	$\Delta\rho$
1914.49	68°.2	0″.68	−1°.7	−0″.16	−0°.7	−0″.13
1916.68	56.5	0.80	−4.7	−0.21	−1.8	−0.18
1918.64	49.2	0.95	−4.6	−0.18	−1.9	−0.13
1919.48	47.9	1.04	−3.8	−0.11	−0.4	−0.06
1920.47	45.4	1.16	−3.4	−0.02	0.0	+0.05
1921.77	39.7	1.07	−5.4	−0.11	−1.4	−0.03

J.C. 2768 A G. Bonn 12479

R.A. $18^h\ 55^m\ 16^s$ Decl. +47° 03′

8.8 8.8 G0

1917.600	225°.6	2″.01	$21^h.5$	2

8965 Winlock *ζ Sagittarii*

R.A. $18^h\ 56^m\ 15^s$ Decl. −30° 01′

3.4 3.6 A2

1914.485	239°.2	0″.40	$18^h.9$	3
.583	239.8	0.45	18.9	3
1916.722	191.8	0.19	18.9	3
.798	197.6	0.19	20.1	3
1917.573	168.7	0.21	19.5	3
1919.470	97.8	0.38	19.1	3
.766	96.7	0.40	19.8	2
1920.628	83.7	0.40	18.8	2
1921.491	78.2	0.41	19.5	3
.516	79.6	0.49	19.3	2
.609	77.6	0.45	18.9	3

This system has made one complete revolution since my orbit was computed in 1900 (*Pop. Astron.* **9**, 57, 1901), but there is no occasion for a revision of the elements, as the following comparison shows:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.53	239°.5	0″.42	+3°.9	−0″.05
1916.76	194.7	0.19	+0.1	−0.03
1917.57	168.7	0.21	+11.4	+0.02
1919.62	97.2	0.39	+2.1	+0.03
1920.63	83.7	0.40	+0.3	−0.04
1921.54	78.5	0.45	+2.2	+0.03

8993 H. N. 126

R.A. $18^h\ 58^m\ 21^s$ Decl. −21° 41′

7.7 7.8 G0

1914.485	268°.8	0″.63	$19^h.0$	3
.583	268.4	0.67	18.7	3
1919.470	258.4	0.88	19.3	3
.766	260.4	0.75	10.1	2
1914.53	268°.6	0″.65	2n	
1919.62	259.4	0.82	2n	

—— H 5084 *γ Cor. Austr.*

R.A. $18^h\ 59^m\ 40^s$ Decl. −37° 12′

5.0 5.0 F8

1919.470	91°.4	2″.13	$18^h.9$	3

9032 Ho 95

R.A. $19^h\ 01^m\ 38^s$ Decl. +27° 08′

8.7 8.7 A0

1922.614	212°.2	0″.31	$21^h.3$	3
.622	211.6	0.36	20.6	2
1922.62	211°.9	0″.34	2n	

9044 Ho 97

R.A. $19^h\ 02^m\ 37^s$ Decl. +31° 35′

9.7 9.7 ——

1922.614	17°.1	0″.66	$21^h.9$	2
.622	15.8	0.65	21.4	2
1922.62	16°.4	0″.66	2n	

9059 Ho 98

R.A. $19^h\ 04^m\ 14^s$ Decl. +26° 56′

8.7 8.7 A0

1922.614	124°.6	0″.28	$21^h.5$	3
.622	126.8	0.31	20.8	2
1922.62	125°.7	0″.30	2n	

The angular motion since discovery in 1886 amounts to about 40°.

9060 Ho 99

R.A. $19^h\ 04^m\ 16^s$ Decl. +30° 22′

9.5 9.7 ——

1922.614	142°.5	0″.34	$21^h.7$	3
.622	143.0	0.31	21.2	2
1922.62	142°.8	0″.32	2n	

Probably very slow direct angular motion.

9114 Secchi 2

R.A. $19^h\ 07^m\ 45^s$ Decl. +38° 37′

8.7 8.7 G5

1914.485	101°.5	0″.46	$20^h.9$	3
.488	100.5	0.48	16.9	3
.676	98.8	0.50	23.5	3
1916.798	94.9	0.51	21.1	4
.856	95.9	0.48	21.6	2
1918.641	95.8	0.53	20.9	3
.649	92.9	0.52	21.2	3
1920.333	93.2	0.62	17.6	3
.338	93.0	0.62	17.3	2
1921.600	91.2	0.57	17.3	3
.655	92.1	0.56	21.1	3

A and BC = Σ 2481 8.0 ——

1914.488	37°.4	4″.31	$17^h.0$	3
1916.856	36.5	4.23	21.8	2

9114—(*Continued*)

According to Russell's elements (*Publ. Lick Obs.* **12**, 138, 1914) the companion is now near the point of apastron.

	θ_0	ρ_0	(O–C) Δθ	Δρ
1914.55	100°3	0″48	+2°1	−0″08
1916.83	95.4	0.50	−0.4	−0.08
1918.64	94.2	0.52	+0.2	−0.07
1920.34	93.1	0.62	+0.7	+0.02
1921.63	91.6	0.57	−0.4	−0.03

9192 β 1256

R.A. $19^{h}\,13^{m}\,35^{s}$ Decl. +6° 09′

9.3 9.7 G5

1922.614	36°7	0″80	$21^{h}1$	3
.622	33.0	0.79	20.3	2
1922.62	34°8	0″80	2n	

9203 Hu 337

R.A. $19^{h}\,14^{m}\,21^{s}$ Decl. +17° 25′

9.0 9.5 ——

1921.861	51°3	0″23	$22^{h}2$	3
.871	53.4	0.24	22.2	3
1921.87	52°4	0″24	2n	

The discovery position is: 1901.51, 68°6, 0″27, 3n.

9219 Howe 47

R.A. $19^{h}\,15^{m}\,38^{s}$ Decl. +2° 45′

8.2 8.4 A2

1922.614	323°2	0″41	$20^{h}6$	3
.622	323.1	0.41	20.0	2
.641	323.3	0.44	18.2	2
1922.63	323°2	0″42	3n	

9237 Hu 338

R.A. $19^{h}\,16^{m}$ 40s Decl. +17° 30′

9.6 9.8 ——

1921.861	114°5	0″36	22.4	3
.871	114.8	0.28	22.4	3
1921.87	114°6	0″32	2n	

9319 Σ 2525

R.A. $19^{h}\,22^{m}\,30^{s}$ Decl. +27° 07′

8.4 8.6 F8

1914.485	307°2	0″83	$21^{h}2$	3
.488	304.6	0.82	17.5	3
1921.655	304.2	0.92	21.4	3
.674	306.0	1.00	21.7	2

The comparison which follows is with Jackson's ephemeris (*M.N.* **80**, 558, 1920):

	θ_0	ρ_0	(O–C) Δθ	Δρ
1914.49	305°9	0″82	+0°7	+0″02
1921.66	305.1	0.96	+3.7	+0.05

9367 Hn 152

R.A. $19^{h}\,26^{m}\,14^{s}$ Decl. −17° 01′

8.8 9.8 G5

1922.614	190°9	0″74	$20^{h}4$	3
.622	189.1	0.67	19.8	2
1922.62	190°0	0″70	2n	

9541 Hu 343

R.A. $19^{h}\,38^{m}\,20^{s}$ Decl. +16° 57′

9.5 9.8 A

1921.861	25°3	0″24	$22^{h}5$	3
.871	25.4	0.23	22.6	3
1921.87	25°4	0″24	2n	

9624 Hu 347

R.A. $19^{h}\,43^{m}\,10^{s}$ Decl. +19° 21′

8.6 11.5 F5

1919.700	334°3	1″06	$21^{h}2$	3
1921.861	335.3	1.05	22.6	3
1920.78	334°8	1″06	2n	

9643 A. G.C. 11 *ζ Sagittae*

R.A. $19^{h}\,44^{m}\,32^{s}$ Decl. +18° 53′

5.3 6.3 A2

1914.485	190°7	0″17	$21^{h}5$	3
.488	188.3	0.18	17.7	3
.498	183.6	0.15	20.8	4
1915.550	183.6	0.21	21.5	4
1916.722	173.6	0.26	21.9	3
.798	177.5	0.24	22.1	3
.856	175.6	0.21	21.4	2
1917.745	177.1	0.24	23.0	3
1918.641	172.2	0.22	21.2	3
.649	170.1	0.25	21.0	3
1919.700	169.5	0.26	21.0	3
1920.338	163.2	0.28	18.0	2
.448	163.7	0.25	17.8	2
1921.650	166.4	0.26	21.6	2
.655	163.7	0.27	21.6	3
.674	165.6	0.29	22.0	2

AB and C = Σ 2585 —— 9.0

1914.488	312°2	8″40	$17^{h}8$	3
1916.722	311.2	8.66	22.2	3
.856	309.8	8.63	21.5	2
1920.448	311.6	8.40	17.9	2
1917.13	311°2	8″52	4n	

The following table gives a comparison of my measures of the close pair with Van Biesbroeck's ephemeris (*A.J.* **29**, 163, 1916):

	θ_0	ρ_0	(O–C) Δθ	Δρ
1914.49	187°5	0″17	−3°9	+0″10
1915.55	183.6	0.21	+2.5	+0.02
1916.79	175.6	0.24	−1.7	±0.00
1917.74	177.1	0.24	+2.4	−0.03
1918.64	171.2	0.24	−2.4	−0.02
1919.70	169.5	0.26	−1.7	−0.06
1920.39	163.4	0.26	−6.8	−0.04
1921.66	165.2	0.27	−2.9	−0.03

9739 Ho 581

R.A. $19^{h} 51^{m} 37^{s}$ Decl. $+41^{m}$ 36′

7.9 8.4 K0

1914.485	22°.4	0″.20	$21^{h}.8$	3
.488	23.3	0.20	17.3	3
1918.641	60.6	0.27	21.6	2
.649	61.3	0.31	21.6	3
1919.626	67.0	0.26	17.5	2
1920.333	68.6	0.41	17.9	2
1921.548	78.1	0.34	18.0	3
.570	76.2	0.34	22.3	3

The following comparison is with Van Biesbroeck's ephemeris (*A.J.* **31**, 169, 1918):

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.49	22°.8	0″.20	−2°.9	−0″.04
1918.64	61.0	0.29	−6.1	−0.01
1919.63	67.0	0.26	−7.4	−0.07
1920.33	68.6	0.41	−11.2	+0.08
1921.56	77.2	0.34	−11.5	±0.00

9771 A. Clark 16

R.A. $19^{h} 53^{m} 47^{s}$ Decl. +26° 59′

8.5 9.0 A0

1921.751	234°.0	0″.43	$22^{h}.7$	3

9772 A. G. 244

R.A. $19^{h} 53^{m} 57^{s}$ Decl. +21° 52′

9.3 10.3 ——

1914.578	272°.5	1″.44	$23^{h}.2$	2
.586	270.6	1.38	22.5	2
1914.58	271°.6	1″.41	2n	

9803 Hu 352

R.A. $19^{h} 55^{m} 51^{s}$ Decl. +17° 40′

9.1 9.4 A0

1921.861	249°.2	0″.22	$22^{h}.8$	3
.871	250.1	0.23	22.8	3
1921.87	249°.6	0″.22	2n	

Hussey's discovery position is 1901.79, 261°.5, 0″.23, 2n.

9979 OΣ 400

R.A. $20^{h} 06^{m} 54^{s}$ Decl. +43° 39′

7.5 8.5 G5

1919.626	340°.6	0″.57	$18^{h}.0$	2
1920.596	338.9	0.57	22.7	2
.645	339.5	0.59	23.1	2
1920.62	339°.2	0″.58	2n	

For 1920.62 Burnham's orbit (*M.N.* **58**, 87, 1898) gives the position 341°.3, 0″.68.

10091 Barnard 11

R.A. $20^{h} 14^{m} 05^{s}$ Decl. +32° 53′

8.5 9.0 B9

1921.751	200°.7	0″.39	$23^{h}.0$	3

AB and C = Ho 592 —— 13.0

1921.751	257°.1	2″.93	$23^{h}.3$	3

10125 Hu 360

R.A. $20^{h} 15^{m} 56^{s}$ Decl. +16° 15′

9.4 9.7 ——

1921.861	316°.6	0″.24	$23^{h}.0$	3
.871	312.2	0.25	23.1	3
1921.87	314°.4	0″.24		

Hussey, in 1901, recorded the angle as 136°.7, calling the components of equal magnitude.

10141 OΣ 406 (=β 362)

R.A. $20^{h} 16^{m} 33^{s}$ Decl. +45° 03′

7.7 7.7 F5

1917.617	19°.5	0″.13	$23^{h}.1$	4
.628	25.8	0.12	23.2	3
1921.579	20.6	0.14	23.1	3

The apparent motion in the half century following discovery by Otto Struve in 1845 was very slow, but during the last few years the change has been rapid and the pair is now extremely difficult to measure. Elongation in the direction given is certain, but the quadrant is indeterminate.

10266 β 63

R.A. $20^{h} 25^{m} 31^{s}$ Decl. +10° 34′

6.0 8.0 A0

1922.646	344°.2	0″.77	$19^{h}.8$	2
.660	343.7	0.85	21.7	2
1922.65	344°.0	0″.81	2n	

10286 See ——

R.A. $20^{h} 26^{m} 52^{s}$ Decl. −16° 57′

7.8 7.8 F0

1922.633	152°.2	0″.16	$20^{h}.7$	2
.660	148.0	0.20	20.3	2
1922.65	150°.1	0″.18	2n	

See on one night in 1897 measured the angle as 119°.8; Hussey, on one night in 1900, as 124°.7. Since the angular separation has diminished it is possible that the companion is now in the fourth quadrant.

10363 β 151 β *Delphini*

R.A. $20^{h} 32^{m} 52^{s}$ Decl. +14° 15′

4.0 5.3 F5

1914.498	279°.1	0″.25	$21^{h}.7$	3
.501	281.6	0.25	22.0	3
.506	285.8	0.22	19.7	3
1915.528	305.1	0.29	21.9	3
.550	306.7	0.30	21.8	4
1917.562	329.1	0.38	23.4	3
.565	325.2	0.39	19.5	2
1919.670	337.7	0.48	19.2	2
1920.640	343.0	0.55	21.9	3
1921.587	344.8	0.62	21.6	3
.606	348.5	0.63	21.6	2

10363—(*Continued*)

The comparison which follows is with an ephemeris computed from my orbit (*Publ. Lick Obs.* **12**, 150, 1914):

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.50	282°2	0″24	+3°7	+0″02
1915.54	305.9	0.30	+2.2	+0.02
1917.56	327.2	0.38	−0.9	−0.02
1919.67	337.7	0.48	−3.2	−0.05
1920.64	343.0	0.55	−2.1	−0.02
1921.60	346.6	0.62	−2.1	+0.01

10372 Hu 200 *τ Capricorni*

R.A. $20^{h}\,33^{m}\,41^{s}$ Decl. −15° 18′

5.8 6.3 B5

1914.498 .641	Too close to measure		$20^{h}0$ 20.6	3 3
1915.550	3°±	0″10±	21.2	3
1921.861	91.9	0.13	21.6	4
.871	85.5	0.15	21.7	3
1921.87	88°7	0″14	2n	

The angle measure in 1915 is quite uncertain. In 1921, the elongation was definite, though the measures were difficult to make.

10403 β 1209

R.A. $20^{h}\,35^{m}\,17^{s}$ Decl. −17° 44′

10.0 10.7 G5

1922.633	300°8	0″32	$20^{h}9$	2
.660	298.3	0.38	20.6	2
1922.65	299°6	0″35	2n	

10407 Ho 135

R.A. $20^{h}\,35^{m}\,26^{s}$ Decl. −14° 52′

7.7 12.2 F0

1922.633	226°8	2″33	$21^{h}2$	2
.660	227.6	2.68	20.9	2
1922.65	227°2	2″50	2n	

10487 β 64

R.A. $20^{h}\,40^{m}\,15^{s}$ Decl. +12° 22′

9.1 9.5 G

1922.646	220°5	0″20	$19^{h}6$	2
.794	220.3	0.20	22.2	3
1922.72	220°4	0″20	2n	

Very rapid angular motion may be expected in this pair during the next few years and the apparent distance may diminish to less than 0″10. In 1876 Dembomski's measures gave 172°4, 0″63.

10517 Ho 141

R.A. $20^{h}\,42^{m}\,38^{s}$ Decl. +18° 56′

9.0 11.0 ——

1922.641	287°2	1″53	$18^{h}6$	2
.646	286.5	1.33	18.6	2
1922.64	286°8	1″43	2n	

10539 Ho 459

R.A. $20^{h}\,43^{m}\,57^{s}$ Decl. +18° 31′

9.8 10.4 ——

1922.641	16°0	0″66	18.8	2
.646	13.9	0.70	18.8	2
1922.64	15°0	0″68	2n	

10559 2729 4 *Aquarii*

R.A. $20^{h}\,46^{m}\,08^{s}$ Decl. −6° 00′

6.3 7.6 F2

1914.498	327°5	0″40	$20^{h}5$	4
.501	327.3	0.43	20.7	3
1920.511	335.4	0.65	22.3	2
.524	337.0	0.63	21.8	2

Comparison with positions computed from my orbit (*Publ. Lick Obs.* **12**, 153, 1914) results as follows:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.50	327°4	0″42	−1°0	−0″03
1920.52	336.2	0.64	−3.1	+0.07

Jackson's elements (*M.N.* **80**, 560, 1920) also represent the measures well and further measures are needed to decide whether his period (151.7 years) or mine (135.6 years) is the better approximation.

10561 See 431

R.A. $20^{h}\,46^{m}\,27^{s}$ Decl. −19° 27′

9.0 13.0 G0

1922.633	340°1	2″14	$21^{h}4$	2
.660	338.5	2.07	21.1	2
1922.65	339°3	2″10	2n	

Cogshall (*A.J.* 486) corrects See's error in the identification of this pair but himself gives incorrect co-ordinates for it. The star is SD−19°5940.

10581 Ho 144

R.A. $20^{h}\,47^{m}\,50^{s}$ Decl. +19° 45′

8.0 8.0 F5, A0

1922.614	171°8	0″19	$22^{h}9$	3
.794	163.2	0.25	22.5	3
1922.70	167°5	0″22	2n	

There has been no change in position angle since discovery in 1886, but the apparent distance has diminished to half its earlier value and the pair is now a difficult one to measure. Miss Cannon finds the spectrum composite.

10607 β 367

R.A. $20^{h}\,50^{m}\,46^{s}$ Decl. +27° 43′

8.5 8.9 G5

1914.676	202°6	0″21	$23^{h}8$	3
.736	204.2	0.15	22.6	3
1920.601	234.9	0.19	23.4	2
.645	237.4	0.19	23.5	2
1921.540	256.4	0.18	19.2	3
.548	250.1	0.20	19.0	3

1914.71	203°4	0″18	2n
1920.62	236.2	0.19	2n
1921.54	253.2	0.19	2n

A plot of the measures from 1876 to date indicates that the angular motion will continue to be very rapid for the next few years. If the pair is regularly observed, it should be possible to compute a fairly good orbit within ten years.

10638 Hu 83

R.A. $20^{h}\ 53^{m}\ 35^{s}$ Decl. $-13^{\circ}\ 36'$

9.1 9.3 F0

1921.861	115°1	0″25	$21^{h}9$	4
.871	115.8	0.23	21.9	3
1921.87	115°4	0″24	2n	

Hussey's discovery position was 1899.59, 76°9, 0″21, 3n.

10643 Σ 2737 *ε Equulei*

R.A. $20^{h}\ 54^{m}\ 05^{s}$ Decl. $+3^{\circ}\ 55'$

5.8 6.3 F5

1914.632	279°0	0″15	$23^{h}0$	2
.635	279.6	0.17	22.6	3
1915.834	266.9	0.14	21.4	3
1916.576	Too close		21.3	2
.593	238±	<0.10	21.5	3
.642	163±	<0.10	22.2	3
1917.658	118∓	0.08	20.4	3
.707	Slight elongation		22.3	3
1918.498	131.6	0.10±	22.2	3
.564	87.6	0.09	22.5	4
.597	78.4	0.09	22.1	4
.608	116.3	0.10±	20.4	4
1919.470	110.8	0.14	20.3	2
.626	111.9	0.12	19.4	2
.766	113.4	0.14	20.7	3
1920.628	105.3	0.20	19.8	2
.640	104.6	0.20	22.2	3
1921.422	108.6	0.25	20.0	3
.587	101.7	0.20	21.9	3

AB and C. —— 7.2

1915.834	73°6	10″90	$21^{h}5$	3

1914.63	279°3	0″16	2n
1915.83	266.9	0.14	1n
1916.60	——	<0.10	3n
1917.68	——	<0.10	2n
1918.57	——	0.10±	4n
1919.61	112.0	0.13	3n
1920.63	105.0	0.20	2n
1921.50	105.2	0.22	2n

A 3000-power eyepiece was used on the close pair in the years 1916-1918; in 1920 and 1921, a power of 1000 was ample. The measures of position angle recorded in the years 1916-18 can only be taken to indicate the general direction of the longer axis of the elongated image. In 1920 and 1921, as in 1914, there was no question as to the quadrant. According to Russell's orbit the position at the epoch 1921.50 should be 108°0, 0″15, and the distance should decrease to a minimum of only 0″02 in 1924.5. After that the distance should steadily increase, with the companion star in the fourth quadrant, until apastron is reached about the year 1971.

10691 β 1211

R.A. $20^{h}\ 58^{m}\ 23^{s}$ Decl. $-18^{\circ}\ 30'$

8.5 9.1 F2

1922.633	340°2	0″57	$21^{h}7$	2
.660	336.0	0.60	21.3	2
1922.65	338°1	0″58	2n	

10749 OΣ 527

R.A. $21^{h}\ 03^{m}\ 01^{s}$ Decl. $+4^{\circ}\ 45'$

6.9 8.4 A2

1922.696	265°5	0″41	$19^{h}5$	2
.718	263.7	0.39	20.4	2
1922.71	264°6	0″40	2n	

10788 Ho 151

R.A. $21^{h}\ 05^{m}\ 54^{s}$ Decl. $+3^{\circ}\ 27'$

9.6 9.8 ——

1922.696	11°8	1″44	19.7	2
.718	9.7	1.39	20.7	2
1922.71	10°8	1″42	2n	

In β's.G.C. the quadrant is given as south but the north component is certainly the fainter of the two.

10833 Hu 767

R.A. $21^{h}\ 08^{m}\ 46^{s}$ Decl. $+15^{\circ}\ 34'$

7.0 7.0 A5

1921.861	101°9	0″16	$23^{h}5$	3
.871	100.3	0.13	23.3	3
1921.87	101°1	0″14	2n	

Hussey's measure in 1904.59 was 163°4, 0″17. The star is misplaced in β's. G.C. because Burnham mistook the 1900.0 position for the one for 1880.0

10839 OΣ 535 *δ Equulei*

R.A. $21^{h}\ 09^{m}\ 37^{s}$ Decl. $+9^{\circ}\ 36'$

5.3 5.4 F5

1914.498	29°0	0″20	$21^{h}9$	3
.501	31.5	0.21	22.2	3
.506	31.1	0.25	19.9	3
1915.503	20.6	0.36	20.5	3
.528	22.4	0.36	22.1	3
.834	21.2	0.28	21.2	3
1916.534	17.5	0.30	22.3	3
.593	14.8	0.23	21.7	3
.733	17.4	0.22	23.4	3
1918.608	197.4	0.14±	20.7	3
1919.670	46.4	0.13±	19.6	2
.766	37.2	0.17	20.4	3
1920.628	27.1	0.31	20.2	2
.640	25.8	0.30	22.4	3
1921.579	20.0	0.36	23.4	3
.587	20.5	0.34	22.4	2

My observing book for 1917 contains a measure recorded as belonging to *δ Equulei*, but it is certainly a mistake, for the measured distance is 0″15, whereas the true distance must have been less than 0″05 and the position angle is approximately 80° in error. The observation has therefore been rejected. A comparison for the other measures with positions computed from my elements (*Publ. Lick Obs.* **12**, 158, 1914) follows:

	θ_c	ρ_c	(O–C) $\Delta\theta$	$\Delta\rho$
1914.50	30°5	0″22	−1°3	+0″01
1915.62	21.4	0.33	−1.8	−0.02
1916.62	16.6	0.25	−0.6	−0.04
1918.61	197.4	0.14±	−1.9	−0.03
1919.72	41.8	0.15±	−4.8	+0.05
1920.63	26.5	0.30	−3.9	+0.05
1921.58	20.2	0.35	−1.9	−0.02

10846 A.G.C. 13 *τ Cygni*

R.A. 21ʰ 10ᵐ 48ˢ Decl. +37° 37′

3.8 8.0 F0

1914.605	209°.8	0″.90	0ʰ.7	4
.676	205.9	0.88	0.4	2
.736	211.8	0.92	22.9	3
1919.670	191.0	0.91	19.7	3
1920.601	183.5	0.96	0.4	3
.640	182.2	0.94	23.2	2
1921.861	178.6	0.95	23.9	3
.871	176.5	1.00	0.1	3

The following comparison is with my ephemeris (*Publ. Lick Obs.* **12**, 161, 1914):

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.67	209°.2	0″.90	−0°.2	+0″.04
1919.67	191.0	0.91	+9.1	−0.04
1920.62	182.8	0.95	+5.6	±0.00
1921.87	177.6	0.98	+6.5	+0.01

10880 β 163

R.A. 21ʰ 13ᵐ 45ˢ Decl. +11° 09′

7.0 9.5 G0

1914.498	262°.6	0″.37	22ʰ.1	3
.501	262.8	0.33	22.3	3
.506	267.3	0.34	20.1	3
1915.528	267.3	0.30	22.3	3
.550	268.2	0.31	22.0	3
1916.538	260.0	0.36	22.5	3
.593	259.8	0.42	21.9	3
.733	257.3	0.35	23.6	3
1920.628	263.5	0.49	20.5	2
.640	261.3	0.53	22.6	2

1914.50	264°.2	0″.35	3n
1915.54	267.8	0.30	2n
1916.62	259.0	0.38	3n
1920.63	262.4	0.51	2n

The companion, after a double conjunction during the interval from 1898 to 1914, is moving out to elongation. The plane of the orbit must lie nearly in the line of sight for the extreme range of the rather discordant observations of position angle is only 20°.

11072 Hu 371

R.A. 21ʰ 30ᵐ 55ˢ Decl. +24° 00′

6.6 7.1 A3

1921.861	189°.4	0″.22	23ʰ.7	3
.871	192.6	0.17	23.8	3
1921.87	191°.0	0″.20	2n	

The position angle shows an increase of nearly 20° since 1901.

11125 β 1212

R.A. 21ʰ 34ᵐ 22ˢ Decl. −0° 30′

7.3 7.8 F8

1914.632	291°.0	0″.48	23ʰ.2	3
.635	291.6	0.46	22.8	3
1921.644	322.4	0.26	23.0	3
.650	321.7	0.21	21.3	3
.674	319.1	0.20	22.3	2
1922.814	40.(?)	<0.10	23.1	3

1914.63	291°.3	0″.47	2n
1921.66	321.1	0.22	3n
1922.81	40.(?)	<0.10	1n

The nearly uniform increase of 1°.5 a year observed in the position angle in the years 1890 to 1914 gave no hint of the rapid change that is shown by the measures in 1921 and 1922. In the latter year the angular separation was so small that the position angle was quite uncertain.

11176 Hu 280

R.A. 21ʰ 37ᵐ 19ˢ Decl. +5° 27′

8.3 8.7 A5

1921.871	179°.1	0″.17	23ʰ.6	3
1922.611	167.8	0.16	22.6	2
.794	168.8	0.21	22.8	3
1922.70	168°.3	0″.18	2n	

The angle measure in 1921 is probably 10° in error, for Hussey, in 1900.62 found 138°.2, 0″.19 (3n).

11179 Ho 165

R.A. 21ʰ 37ᵐ 19ˢ Decl. +18° 29′

8.2 8.4 K0

1922.696	66°.3	0″.55	20ʰ.2	3
.794	64.9	0.56	23.3	3
1922.74	65°.6	0″.56	2n	

11210 Ho 166

R.A. 21ʰ 39ᵐ 26ˢ Decl. +27° 23′

8.6 8.8 F5

1914.764	236°.5	0″.32	19ʰ.9	3
.890	238.4	0.29	1.7	3
1915.834	229.6	0.26	23.8	3
.848	232.6	0.27	0.5	2
1917.573	223.8	0.28	23.8	3
1918.770	220.0	0.25	20.4	3
1919.670	215.0	0.23	20.3	3
1920.563	208.8	0.24	0.4	3
.601	207.9	0.27	1.0	3
1921.861	204.5	0.29	0.2	3
.871	204.2	0.25	0.4	3
1922.696	199.7	0.27	20.0	2
.794	197.5	0.27	23.1	3

1914.83	237°.4	0″.30	2n
1915.84	231.1	0.26	2n
1918.67	219.6	0.25	3n
1920.58	208.4	0.26	2n
1921.87	204.4	0.27	2n
1922.74	198.6	0.27	2n

11214 Σ 2822 *μ Cygni*

R.A. 21ʰ 39ᵐ 40ˢ Decl. +28° 18′

4.7 6.1 F5

1916.798	136°.4	1″.56	0ʰ.2	3
1921.540	135.5	1.19	20.9	3
.548	135.9	1.16	19.6	2
1921.54	135.7	1″.18		

11222 β 989 *κ Pegasi*

R.A. $21^h 40^m 07^s$ Decl. +25° 11′

5.0 5.1 F5

1914.506	159°.9	0″.13	$20^h.8$	3
.605	164.2	0.14	1.0	3
.764	145.5	0.14	20.2	3
.890	150.6	0.17	1.5	3
1915.834	132.2	0.24	23.6	3
.848	129.4	0.22	0.3	3
1917.573	119.1	0.28	23.5	3
.592	112.7	0.27	18.9	3
1918.770	104.5	0.22	20.2	3
1919.670	95.6	0.18	20.0	3
1920.563	23.±	0.13±	23.8	3
1921.540	299.9	0.14	20.7	3
.600	301.4	0.13	19.8	3
1922.814	282.0	0.21	23.7	3
.890	277.3	0.17	23.5	3

Lewis's elements (*Mem. R.A.S.* **56**, 653, 1906) represent the measures for the years 1914 to 1919 very well. My measure in 1920 was marked "uncertain," and the residuals for that year are of little significance; but in 1921 the distance was decidedly less than 0″.2.

	θ_0	ρ_0	(O–C) Δθ	Δρ
1914.69	155°.0	0″.14	+5°.7	±0″.00
1915.84	130.8	0.23	+0.2	+0.01
1917.58	115.9	0.28	−2.2	−0.01
1918.77	104.5	0.22	−6.2	−0.05
1919.67	95.6	0.18	−5.5	+0.02
1920.56	23.±	0.13±	+66.±	+0.07±
1921.57	300.2	0.14	+14.2	−0.07
1922.85	279.6	0.19	+7.6	±0.00

11256 Barnard 15

R.A. $21^h 42^m 31^s$ Decl. −2° 11′

9.3 10.0 F2

1915.610	85°.4	0″.41	$22^h.8$	2
1922.671	89.7	0.38	21.5	3
.794	91.1	0.40	21.9	3
1922.73	90°.4	0″.39	2n	

In 1900.53 my measured position was 78°8, 0″.36.

11346 β 75

R.A. $21^h 50^m 38^s$ Decl. +10° 25′

8.4 9.0 G5

1922.696	51°.7	0″.94	$20^h.4$	3
.718	52.0	0.98	20.9	3
1922.71	51°.8	0″.96	2n	

The angular change in 47 years is less than 20°, but the components are moving together at the rate of nearly 0″.2 annually, and the apparent distance seems to be diminishing.

11464 β 696

R.A. $21^h 59^m 41^s$ Decl. +15° 25′

8.5 9.0 G5

1922.696	354°.3	0″.46	$20^h.6$	3
.718	354.4	0.49	21.2	3
1922.71	354°.4	0″.48	2n	

11476 Harvard 169

R.A. $22^h 00^m 51^s$ Decl. −2° 33′

9.5 11.0 G5

1913.721	29°.9	2″.36	23°.2	2
.726	31.5	2.41	19.8	2
1913.72	30°.7	2″.38	2n	

13610 Hu 977

R.A. $22^h 02^m 01^s$ Decl. +65° 10′

9.0 9.5 ——

1921.861	308°.2	0″.24	$1^h.0$	3
1922.718	308.6	0.30	19.6	3
1922.29	308°.4	0″.27	2n	

11642 Hu 383

R.A. $22^h 14^m 51^s$ Decl. +20° 37′

9.1 9.1 ——

1921.871	36°.9	0″.25	$0^h.7$	2
1922.794	34.6	0.32	0.3	2
1922.33	35°.8	0″.28	2n	

11691 β 172 51 *Aquarii*

R.A. $22^h 18^m 54^s$ Decl. −5° 21′

6.5 6.6 A0

1914.632	353°.7	0″.58	$23^h.4$	3
.635	353.7	0.54	23.0	3
1921.606	348.6	0.63	22.1	2
.614	350.5	0.58	22.0	3
1914.63	353°.7	0″.56	2n	
1921.61	349.6	0.60	2n	

11761 Krueger 60

R.A. $22^h 24^m 28^s$ Decl. +57° 12′

9.3 10.8 ——

1920.667	27°.5	1″.64	$0^h.8$	3
.678	26.2	1.65	0.2	2
.681	27.2	1.70	0.9	3
1921.548	14.2	1.65	20.7	2
.559	15.3	1.70	20.0	3
.617	12.0	1.64	21.2	3
.861	11.5	1.55	0.7	2

	θ_0	ρ_0	(O–C) Δθ	Δρ
1920.68	27°.0	1″.66	−3°.0	+0″.13
1921.65	13.3	1.64	−7.3	+0.29

The comparison is with positions computed from Russell's second orbit, period 54.9 (*A.J.* **30**, 131, 1917). The more recent orbit by Pavel and Bernewitz (*A.N.* **211**, 121, 1920) gives larger residuals in both co-ordinates. According to Adams the star A belongs to the spectral class Mb.

11763 Σ 2912 37 *Pegasi*

R.A. 22ʰ 24ᵐ 55ˢ Decl. +3° 55′

5.7 7.1 F5

1914.635	276°±	0″10±	23ʰ2	3
.660	299.±	0.10±	21.4	3
1915.528	323.±	0.10±	22.6	3
.676	42.±	0.10±	22.5	3
1916.538	358.±	<0.10	23.0	3
.642	326.±	0.10±	22.6	3
1921.516	117.9	0.14	22.7	3
.537	113.3	0.20	21.4	2
.540	115.8	0.17	21.2	3
1921.53	115°7	0″17	3n	

The measures of position angle in the years 1914-1916 are obviously very uncertain. Estimates on five good nights in the years 1917-1919 are even more uncertain and have been rejected as having no value beyond showing that the angular distance must then have been very small. It was estimated as not exceeding 0″10. The distance in 1921 was probably smaller than the measured value, but the following star seemed definitely the fainter of the two. If this is correct, the distance will increase steadily for the next half century.

11770 Hu 388

R.A. 22ʰ 25ᵐ 28ˢ Decl. +21° 57′

8.6 9.1 F0

1921.871	185°9	0″24	1ʰ0	2
1922.794	183.8	0.24	0.5	2
1922.33	184°8	0″24		

For the date 1901.73, Hussey's measures give 141°3, 0″24, 3n.

13620 Hu 981

R.A. 22ʰ 27ᵐ 00ˢ Decl. +61° 07′

7.5 7.7 A0

1921.861	241°5	0″23	1ʰ5	3
1922.718	236.8	0.21	20.0	3
1922.29	239°2	0″22		

This is now a comparatively easy pair to measure with the 36-inch. In 1904.70 Hussey's measures gave 254°0, 0″10, 2n.

13622 Hu 983

R.A. 22ʰ 30ᵐ 36ˢ Decl. +65° 19′

8.3 8.5 K0

1921.861	163°5	0″27	1ʰ2	3
1922.718	162.7	0.29	19.8	3
1922.29	163°1	0″28	2n	

11862 β 1092

R.A. 22ʰ 33ᵐ 34ˢ Decl. +72° 22′

8.2 8.2 F5

1914.649	219°3	0″34	1ʰ2	
.653	215.2	0.32	21.1	
1915.522	213.5	0.27	20.8	
.561	215.9	0.27	21.2	
1916.817	216.3	0.26	21.0	
1920.670	216°5	0″30	21ʰ0	
.678	221.6	0.40	0.5	
1921.600	218.0	0.32	20.7	
.617	219.3	0.32	20.8	
1918.09	217.3	0.31	9n	

The two components are so nearly equal in brightness that the quadrant is quite indeterminate. Though these measures give little indication of motion, comparison with earlier observations shows that the apparent orbit is a very elongated ellipse, and it is probable that the distance will diminish rapidly in the next few years.

11873 Ho 295

R.A. 22ʰ 34ᵐ 33ˢ Decl. +43° 47′

7.5 7.5 G0

1914.506	154°9	0″34	21ʰ1	3
.660	155.9	0.26	20.2	3
1916.505	157.6	0.27	20.4	3
.524	154.0	0.27	20.3	2
1918.663	153.2	0.18	20.2	3
.674	153.8	0.21	20.8	2
1920.667	nf−sp.	0.10±	1.4	3
.681			1.4	4
1921.559	325.7	0.17	20.6	2
.600	343.9	0.16	20.5	3
.622	342.6	0.15	21.3	2
.707	336.1	0.18	20.8	3

1914.58	155°4	0″30	2n
1916.51	155.8	0.27	2n
1918.67	153.5	0.20	2n
1920.67	nf.-sp.	0.10±	2n
1921.62	337.1	0.16	4n

The few measures made from discovery, in 1887, to 1902, indicated little change, but in 1906 the pair was too close to measure with the 36-inch, and in 1912, my measures gave results agreeing substantially with those secured in 1914. In 1920 the angular distance was again so small that the position angle could only be estimated as probably north-following, south-proceeding. The components are of nearly equal brightness, but the evidence favors the conclusion that the quadrant was reversed in the interval 1902-1912 and again about 1920 and that the inclination of the orbit plane does not differ greatly from 90°. Unfortunately, the few measures do not suffice to fix with any accuracy the values or the dates of the two elongation distances.

11979 β 1146

R. A. 22ʰ 43ᵐ 45ˢ Decl. +30° 34′

7.7 8.5 B9

1914.506	286°0	0″12	21ʰ7	3
.605	280.1	0.14	1.2	3
1918.770	263.9	0.14	21.0	3
1920.546	259.4	0.17	20.3	2
.628	265.0	0.15	21.3	2
.681	260.4	0.13	1.6	3

1914.56	283°0	0″13	2n
1918.77	263.9	0.14	1n
1920.62	261.6	0.15	3n

These measures clearly show that the angular motion is retrograde. The earlier measures are discordant.

12008 Ho 482

R.A. 22^h 46^m 29^s Decl. +25° 52′

7.3 7.5 A3

1915.834	207°0	0″23	0^{h}8	2
.848	207.4	0.19	1.6	2
1917.636	196.1	0.21	1.1	3
1918.770	191.0	0.22	20.8	3
1920.628	186.5	0.24	21.7	2
.681	183.6	0.25	1.8	3

1915.84	207°2	0″21	2n
1917.64	196.1	0.21	1n
1918.77	191.0	0.22	1n
1920.65	185.0	0.24	2n

12036 *β* 382

R.A. 22^h 49^m 12^s Decl. +44° 13′

5.8 7.8 A0

1916.741	249°4	0″53	1^{h}4	2
1921.707	267.8	0.44	21.1	3
.737	268.7	0.44	21.0	2
1921.72	268°2	0″44	2n	

12046 *β* 178

R.A. 22^h 50^m 00^s Decl. −5° 31′

6.0 8.0 G5

1922.696	325°4	0″42	22^{h}3	2
.718	327.3	0.39	22.5	2
1922.71	326°4	0″40	2n	

There has been very little change in the position angle since discovery in 1875, but the apparent distance has now diminished to about one half its maximum observed value.

12090 OΣ 536

R.A. 22^h 53^m 31^s Decl. +8° 50′

7.2 7.3 G0

1915.528	166°7	0″11	23^{h}0	3
1916.642	169.8	0.12	23.3	3
1917.658	162.2	0.16	21.4	3
.715	164.2	0.19	23.3	3
.745	168.8	0.18	23.8	3
1918.531	163.3	0.21	22.5	3
1920.628	162.7	0.25	22.1	2
1921.537	165.8	0.24	21.6	3
.540	164.0	0.27	21.4	3

On three good nights in 1914 (mean epoch, 1914.64), the pair was too close for satisfactory measures. Elongation in a general preceding following direction was noted, and the distance was estimated as not over 0″10. There is but little change in the position angle when the components are separately visible and the stars are so nearly equal in brightness that it is impossible to say whether a single or a double conjunction occurred in the interval 1912 to 1914.

12096 Barnard 18 2 *Piscium*

R.A. 22^h 54^m 20^s Decl. +0° 26′

5.6 13.5 K0

1918.570	88°0	3″54	23^{h}4	2
1921.737	89.8	3.50	21.5	2
1922.696	88.9	3.57	22.5	2
.718	89.4	3.83	22.2	2

1921.43	89°0	3″61	4n

12110 H 3158

R.A. 22^h 55^m 36^s Decl. +70° 14′

9.3 9.3 A2

1915.522	210°3	0″97	21^{h}2	3
.618	209.1	0.83	21.2	3
1915.57	209°7	0″90	2n	

12125 *β* 1147 2 *Andromedae*

R.A. 22^h 58^m 00^s Decl. +42° 13′

5.1 A2

On two good nights in 1914, one in 1918, and one in 1921, I failed to find any trace of the companion, using powers to 1500.

13641 Hu 994

R.A. 23^h 03^m 43^s Decl. +63° 06′

6.9 6.9 B3

1921.861	311°0	0″21	1^{h}7	3
1922.718	315.7	0.26	20.2	3
1922.29	313°4	0″24	2n	

12214 Ho 197

R.A. 23^h 06^m 41^s Decl. +37° 41′

8.2 8.7 F5

1922.696	85°4	0″33	21^{h}3	2
.843	85.8	0.33	1.2	3
1922.77	85°6	0″33	2n	

In 1906 Burnham thought there was no evidence of change since discovery in 1885, but the present measures establish the fact of retrograde angular motion and indicate a slow decrease in the apparent distance.

12273 *β* 992

R.A. 23^h 11^m 38^s Decl. +63° 34′

8.7 8.8 F0

1914.649	137°7	0″20	1^{h}5	3
.653	135.9	0.24	21.3	3
1916.817	131.8	0.24	21.2	3
1920.582	128.0	0.21	21.4	2
.670	131.1	0.22	21.9	3
.678	126.3	0.24	0.8	3
1921.800	126.7	0.21	20.9	3
.830	129.4	0.23	21.2	3

1914.65	136°8	0″22	2n
1916.82	131.8	0.24	1n
1920.64	128.5	0.22	3n
1921.82	128.0	0.22	2n

12276 β 79

R.A. 23^h 12^m 28^s Decl. −2° 04′

8.6 9.6 G5

1915.676	66°8	1″00	23^{h}4	3
.834	66.4	1.05	22.6	2
1921.694	63.1	0.97	22.5	3
.729	61.4	1.00	22.0	2
1915.75	66°6	1″02	2n	
1921.71	62.2	0.98	2n	

12280 Hu 400

R.A. 23^h 12^m 39^s Decl. +17° 46′

6.9 8.5 F0

1922.718	213°4	0″40	21^{h}9	3
.794	214.2	0.39	1.6	2
1922.76	213°8	0″40	2n	

Hussey's measure is: 1901.78, 249°1, 0″32, 3n.

12285 β 717

R.A. 23^h 13^m 06^s Decl. +48° 28′

5.0 13.0 Ma

1922.696	160°2	7″70	21^{h}5	2
.843	163.1	7.76	1.4	3
1922.77	161°6	7″73	2n	

If the proper motion assigned to the bright star by Auwers (0″024 in 119°8) is correct, the system is certainly a physical one, for the measures show no relative motion since 1878.

12290 β 80

R.A. 23^h 13^m 46^s Decl. +4° 52′

8.9 9.9 G5

1914.619	236°5	0″57	23^{h}9	2
.632	231.3	0.53	0.4	3
.635	237.6	0.54	0.0	3
1915.676	237.8	0.64	23.5	3
.834	240.8	0.63	23.3	3
1916.733	236.3	0.66	0.2	3
1917.715	244.7	0.67	23.7	3
.745	245.7	0.64	0.2	3
1920.628	252.4	0.73	22.8	2
.645	252.1	0.70	0.5	2
1921.694	253.1	0.67	22.2	3
.729	251.3	0.71	21.8	2

The following comparison is with Jackson's ephemeris (*M.N.* **80**, 561, 1920):

	θ_0	ρ_0	(O–C)$\Delta\theta$	$\Delta\rho$
1914.63	235°1	0″55	+1°2	−0″03
1915.75	239.3	0.64	+1.7	+0.03
1916.73	236.3	0.66	−4.4	+0.02
1917.73	245.2	0.66	+1.7	±0.00
1920.64	252.2	0.72	+1.5	−0.01
1921.71	252.2	0.69	−0.9	−0.04

12404 β 1266

R.A. 23^h 25^m 29^s Decl. +30° 17′

8.0 8.1 F5

1914.506	207°2	0″11	21^{h}9	3
.605	200.5	0.13	1.5	4
1915.862	193.9	0.17	2.1	3
1916.713	183°3	0″18	1^{h}9	4
1918.770	173.8	0.15	21.4	2
1919.670	141.7	0.18	20.8	2−
1920.667	144.9	0.17	1.8	2
.681	136.9	0.23	2.0	3
1921.559	135.6	0.16	20.9	2
.600	129.4	0.17	21.6	3
1923.024	129.6	0.22	2.5	2

My measures of this pair are unusually discordant, but unless those here recorded are also affected by a large systematic error the revolution period given in my preliminary set of elements (*Publ. Lick Obs.* **12**, 181, 1914) is too short by about four years. I have derived a new set of elements, by graphical methods, but it must also be regarded as merely provisional. The companion should return to its discovery position in about eight years. Taking the mass to be 1.7 times that of the Sun, the new elements give +0″016 for the hypothetical parallax and +4.3 and +4.4 for the absolute magnitudes of the components. There are no published parallax values.

Elements

$P =$ 40 years $\omega =$ 133°
$T =$ 1909.8 $i =$ 48
$e =$ 0.33 $\Omega =$ 46
$a =$ 0″22 $n =$ −9.0

Ephemeris

1923.8	117°1	0″19
1925.8	103.1	0.21
1927.8	91.5	0.23
1929.8	81.7	0.25
1931.8	73.0	0.26

Measures and Residuals

					(O–C)	
		θ_0	ρ_0		$\Delta\theta$	$\Delta\rho$
1891.69	74°0	0″24	3n	β	+0°5	−0″02
1893.54	65.9	0.23	1	Lv	−0.3	−0.04
3.64	73.3	0.26	2	W	+7.5	−0.01
3.67	60.3	0.22±	7	Sp	−5.4	−0.05
1895.96	55.5	0.20±	2	Sp	−3.3	−0.07
1896.78	52.0	0.28	2	L	−1.3	+0.02
1897.95	44.8	0.36	1	L	−3.7	+0.10
1898.71	54.0	0.35	1	L	+8.7	+0.10
1899.55	45.5	0.24	3	A	+3.4	±0.00
9.84	47.0	0.22	2	L	+6.9	=0.02
1900.59	41.3	0.24	3	A	+5.0	+0.01
1901.01	31.7	0.14	1	Green	−2.4	−0.08
1.88	13.8	0.22	4	Green	−15.1	+0.01
1902.82	13.1	0.19	5	Green	−9.3	±0.00
1903.80	32.3	0.30	3	van B.	+17.1	+0.13
3.95	22.1	0.13	1	Green	+8.3	−0.04
1904.50	11.1	0.18	1	A	+3.1	+0.02
1905.63	359.0	0.14	2	A	+6.2	+0.01
1906.50	321.1	0.12	2	A	−15.9	±0.00
1907.60	297.5	0.14	2	A	−14.0	+0.04
1908.72	302.9	0.14	2	A	+19.0	+0.03
1910.84	250.0	0.16	1	J	+4.8	+0.02
10.98	245.0	0.15	1	V	+1.7	+0.01
1911.60	250.7	0.18	3	A	+15.3	+0.02
1912.62	239.4	0.17	3	A	+15.4	+0.01

12404—(*Continued*)

	θ_0	ρ_0			(O–C) $\Delta\theta$	$\Delta\rho$
1913.79	206°.4	0".16	1	Green	−5°.8	±0".00
1914.56	203.8	0.12	2	A	−0.9	+0.06
1915.86	193.9	0.17	1	A	+1.6	±0.00
1916.71	183.3	0.18	1	A	−0.7	+0.01
1918.77	173.8	0.15	1	A	+10.4	+0.01
1919.67	141.7	0.18	1	A	−12.6	+0.01
1920.67	140.9	0.20	2	A	−3.5	+0.03
1921.58	132.5	0.17	2	A	−3.4	−0.01
1923.02	129.6	0.22	1	A	+5.4	+0.03

12419 Hu 298

R.A. $23^{h}\ 27^{m}\ 07^{s}$ Decl. +6° 32′

7.5 7.6 F5

1914.632	27°.7	0".18	0h.6	3
.635	29.6	0.17	0.2	3
1917.715	62.5	0.17	23.9	3
1920.628	100.3	0.18	23.0	2
1921.540	110.4	0.20	22.4	3
.579	106.1	0.16	0.1	3

1914.63	28°.6	0".18	2n
1917.72	62.5	0.17	1n
1920.63	100.3	0.18	1n
1921.56	108.2	0.18	2n

Hussey's discovery position was: 1900.76, 94°.6, 0".17, 3n. It is therefore quite possible that the revolution period is less than 20 years, but the lack of measures in the interval 1900-1914 prevents the computation of an orbit at this time. Hussey gives the magnitudes as 6.8, 7.4; to me the two components appear almost equally bright. The photometric magnitude of the pair is 6.84.

12432 β 720 72 *Pegasi*

R.A. $23^{h}\ 28^{m}\ 59^{s}$ Decl. +30° 49′

6.0 6.0 K2

1914.506	184°.8	0".42	22h.0	3
.605	185.4	0.41	1.7	4
1918.770	193.6	0.36	21.6	3
1921.707	195.7	0.36	21.3	3
.727	197.9	0.46	21.0	3

1914.56	185°.1	0".42	2n
1918.77	193.6	0.36	1n
1921.72	196.8	0.41	2n

In 1918 and in 1921 I noted the northern component as certainly the fainter of the two; but I have given the quadrant to correspond with the earlier published measures which are numerous enough to show that the angular motion since discovery in 1878 amounts to less than 70°.

12468 OΣ 500

R.A. $23^{h}\ 32^{m}\ 39^{s}$ Decl. +43° 53′

6.3 7.0 B9

1922.696	333°.9	0".62	21h.8	2
.843	332.0	0.60	1.6	3
1922.77	333°.0	0".61	2n	

12484 β 856

R.A. $23^{h}\ 33^{m}\ 54^{s}$ Decl. +70° 04′

8.6 9.6 A3

1915.522	279°.5	0".53	22h.0	3
1921.830	282.2	0.56	21.5	3
.839	282.4	0.47	21.5	3
1921.83	282°.3	0".52	2n	

12562 β 995

R.A. $23^{h}\ 42^{m}\ 35^{s}$ Decl. +46° 17′

5.9 8.4 B3

1922.696	240°.2	0".82	22h.0	2
.843	239.2	0.86	1.8	3
1922.77	239°.7	0".84	2n	

12637 Hu 500

R.A. $23^{h}\ 50^{m}\ 59^{s}$ Decl. +22° 54′

8.9 8.9 G0

1921.628	90°.2	0".19	22h.5	3
.707	83.4	0.22	21.9	3
1921.67	86°.8	0".20	2n	

12664 β 730

$23^{h}\ 53^{m}\ 33^{s}$ Decl. −4° 07′

5.1 10.8 K0

1922.696	275°.3	1".51	22h.8	2
.794	276.3	1.58	1.1	3
1922.74	275°.8	1".54	2n	

12680 Weisse 45

R.A. $23^{h}\ 54^{m}\ 43^{s}$ Decl. +1° 19′

9.6 10.1 F8

1922.696	88°.3	1".81	23h.0	2
.794	88.6	1.86	1.3	3
1922.74	88°.4	1".84	2n	

12701 β 733 85 *Pegasi*

R.A. $23^{h}\ 56^{m}\ 57^{s}$ Decl. +26° 33′

5.8 11.0 G0

1914.506	113°.4	0".57	22h.3	3
.660	117.3	0.62	21.8	3
.764	118.6	0.79	21.8	4
.822	119.6	0.65	21.2	3
1915.848	136.0	0.71	2.5	3
1916.713	144.6	0.79	2.7	4
1917.636	148.2	0.69	2.2	2
1920.681	180.1	0.83	2.4	4
1921.600	190.0	0.69	22.0	3
.622	190.0	0.75	21.9	2
.628	191.8	0.72	22.7	3

Comparison with positions computed from the elements by Bowyer and Furner (*M.N.* **66**, 423, 1906) leads to the following residuals:

	θ_0	ρ_0	(O–C) $\Delta\theta$	$\Delta\rho$
1914.69	117°.2	0".66	−15°.0	−0".13
1915.85	136.0	0.71	−5.1	−0.10
1916.71	144.6	0.79	−2.8	−0.03
1917.14	148.2	0.69	−6.1	−0.12
1920.68	180.1	0.83	+1.3	+0.07
1921.62	190.6	0.72	+3.7	−0.02

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ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 349

THE PHOTOELECTRIC PHOTOMETER OF THE LICK OBSERVATORY AND SOME RESULTS OBTAINED WITH IT

Introduction

After the work of Elster and Geitel[1] and others had shown that the photo-electric cell could be used as an accurate light-measuring instrument, astronomers were quick to adopt such cells for use in stellar photometry. The pioneers were Guthnick and Prager[2] at the Berlin-Babelsberg Observatory and Rosenberg[3] at Tübingen. The work was taken up first in this country by Stebbins and Kunz[4] at the University of Illinois. More rcently, A. F. and F. A. Lindemann[5] have published a description of their photometer at Sidmouth, England. At a number of other observatories plans are being made for the installing of this type of instrument.

Weather conditions at Mt. Hamilton are such as to encourage the undertaking of photo-electric photometry here. In summer we generally have many consecutive weeks when no clouds appear and the transparency of the sky remains nearly constant. At that time, also, the humidity is very low, remaining below 10 per cent for days at a time. Under these conditions electric instruments are easy to operate, for one need not contend with those leakage effects which can become troublesome in damp weather.

Encouraged by the success attained elsewhere, I undertook to install a photo-electric photometer at this observatory. From its inception the project received the enthusiastic support of Director Campbell, who took a keen interest in every phase of the work and ungrudgingly devoted to its completion the resources of the observatory. The funds used were in part those given by Mrs. Phoebe A. Hearst for another purpose, but applied with her permission to the building of this instrument. Mrs. Hearst's grant was supplemented by money from the observatory maintainance fund. Dr. Dershem of the Physics Department of the University kindly agreed to accept direction of the preliminary work which was done at Berkeley. Having assisted Professor Stebbins for some time, Dr. Dershem was well informed as to the problems in this field, and he generously put at my disposal the results of his experience. I am glad of this opportunity to acknowledge my indebtedness to him for his unfailing kindness and for the careful attention which he gave to the work done under his direction.

The first sketches for the photometer were made by the writer. These plans were modified and greatly improved by Mr. M. A. Silva, Chief Mechanician of the observatory, who made the working drawings and constructed the instrument, except the electrometer section. Special credit is due Mr. Silva for the exercise of great care and skill in this work; he spared no pains to make the photometer efficient in every way, keeping specially in mind considerations of the observer's convenience. The satisfactory performance of the instrument has amply justified the pains taken in its construction. Thanks for valuable advice and assistance are due also to other members of the Lick Observatory staff, to other members of the Physics Department (particularly Professor E. P. Lewis and Mr. Chas. T. Dozier), to Mr. Wm. H. Taylor then of the U. S. Bureau of Standards, and to Dr. Harlow Shapley.

In what follows, many processes are described and facts mentioned which are in no sense new; they are given here for the sake of completeness and with the hope that they may be useful to others who plan to undertake work of this nature.

Some Requirements of the Design

Limitations as to Weight, Rigidity, and Rotation. Some of the primary limitations for the photometer were dictated by the character of the 12-inch (30.5 cm.) telescope; this telescope has an old-style mounting and a small driving clock, and in general is not adapted to carrying a heavy auxiliary instrument. For this reason it was necessary to keep down the weight of the photometer. At the same time, rigidity is required lest on account of flexure the incident light fall upon slightly different parts of the cell, according to the position of the object observed; since the hydride surface varies in sensitiveness from point to point, it is obvious that such a variation in the position of the beam will produce errors, even though the danger be lessened by having the beam out of focus when it strikes the cell. Another requirement is that there be means for rotating the photometer about the axis of the telescope. The Lick Observatory 12-inch refractor is not equipped with a rotatable tail-piece, and so the means of rotating must be provided in the photometer.

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[1] *Phys. Zeitsch.* **11**, 212, 1910; **12**, 609, 1911; **13**, 739, 1912. *Wied. Ann.* **48**, 625, 1893.

[2] *Veröffent. Sternwarte Berlin-Babelsberg,* **1**, part 1, 1914; **2**, part 3, 1918.

[3] *V. J. S. der A. G.*, **48**, 210, 1913.

[4] *Ap. Jour.* **39**, 484, 1914. *Pop. Astron.* **22**, 631, 1914.

[5] *M. N. of R. A. S.*, **79**, 343, 1919.

Electrometer. Depth of Focus, Magnification and Rigidity. Because of the war it was not possible to follow the original plan of purchasing a string electrometer, preferably of the Lutz[6] design. It was necessary, therefore, to undertake the construction of such an instrument. With the approval of Professor E. P. Lewis, the Physics Department of the University kindly agreed to make it in their Department shop, and Dr. Dershem consented to supervise the work, which was carried out by the Chief Mechanician, Mr. W. R. Stamper. The construction of the instrument was facilitated through the kindness of Professor Stebbins, who let us have the design for an electrometer made for him by the Gaertner Company. Using this design as a guide, Mr. Stamper drew new plans into which he incorporated his own ideas and several changes suggested by Dr. Dershem and the writer. It was especially desired to make the microscope more rigid, in order to eliminate those minute motions which sometimes cause zero-shifts. (See next paragraph.) Also it was desired to increase the magnification of the thread but at the same time to have an increased depth of focus; other observers have been annoyed by the fact that the thread, as it crosses the field of view, sometimes sways back and forth in the line of sight, thus getting out of focus and rendering the measures difficult. Depth of focus can be obtained by using a low-power objective; increased magnification, by an unusually large tube-length. But it is undesirable to make the microscope very long because rigidity would be sacrificed and the chances increased of striking the microscope accidentally while observing. Director Campbell suggested that the difficulty be circumvented by attaining the longer tube-length with a prism system. Accordingly a 2-prism microscope was designed which has an actual length of 132 mm. and an optical path equivalent of 380 mm. in air; the magnification of the thread is 350 diameters. With the above design there is sufficient depth of focus so that the instrument has not given any trouble in that respect. The optical performance of the microscope is good, despite the fact that the objective is designed for a much shorter tube-length.

Precautions Against Zero-shift. One of the corrections which must be applied to measures with an electrometer of this kind is for shift of the zero point. Suppose that, when grounded, the thread is at scale division x. Then the drift of the thread is watched through A divisions, and is observed to have a drift of A divisions in B seconds. If the thread is now grounded again and does not come back to x but to $x+\Delta x$, the rate $\frac{\text{A divisions}}{\text{B seconds}}$ must be corrected by the amount $\frac{\Delta x \text{ divisions}}{\text{B seconds}}$. This zero-shift can be traced to several causes. One is friction in the bearings of the gimbals supporting the electrometer; such friction prevents the electrometer from always coming promptly to the vertical position. Another cause is lack of rigidity of the microscope; a very slight "creeping" could produce a large apparent motion of the zero-point, and when the observer accidentally brushes against the microscope the effect is at once evident if the microscope has any "play." A third cause is imperfection in the temperature compensation. On this account the tension of the thread changes, and this is accompanied by a change in the zero-point. The zero reading depends upon the tension of the thread for this reason: the string is not perfectly straight even when at zero-point, because it is grounded to the center of the knife battery and therefore never at exactly zero potential.

In designing the present instrument special effort was made to eliminate as far as possible the effects mentioned above. Friction in the gimbals was combatted by providing these with ball-bearings. Rigidity of the electrometer microscope is increased by making the tube short and fastening it with numerous strong screws. The problem in computing the temperature compensation was to find what proportions must be adopted for the amber, brass and other materials of the suspension so that its expansion would approximately equal that of the brass housing. Since different samples of amber vary widely in their characteristics, it was necessary to know the coefficient of expansion of the particular piece employed. Mr. C. G. Peters of the U. S. Bureau of Standards very kindly took the necessary measures by an accurate interferometer method. He found that the increase in length in μ per centimeter from 0°C to any temperature t is

$$\Delta L = .4910\ t + .00159\ t^2$$

The mean coefficient of expansion is

$$\text{C.E. } 0° \text{ to } 25° = 45.2 \times 10^{-6}$$

$$\text{C.E. } 0° \text{ to } 100° = 57.2 \times 10^{-6}$$

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[6] *Phys. Zeitschr.* **13**, 954, 1912.

By a comparison of several tables, values were adopted for the probable coefficients of expansion for the various other materials in the suspension under the conditions to be anticipated in practical use of the instrument. The following dimensions were determined:

From top to bottom,

Amber	13.5 mm.	
Brass	22	
Silver	10	
Platinum	75	
Silver	10	
Brass	20	
Amber	10	
Nickel-steel	6	or 50
Brass	64	20

The pairs of values give the range of proportions in the temperature compensation; 6 and 64 when the clamp is at the bottom, 50 and 20 when it is at the top. The exact position for the clamp was found later by experiment.

Sectored Disks. It has been frequently pointed out that the accuracy of photo-electric measures is decreased if the two light sources to be compared differ too much in brightness. When one is observing stars it is advisable to reduce the brighter one artificially to within one-half magnitude of the fainter; an even closer equality is to be desired. For this purpose Guthnick and Prager have employed objective diaphragms; the University of Illinois observers, neutral-tinted shade-glasses near the focus. Each of these methods is subject to disadvantages. With the first, it is necessary to have a cumbersome apparatus at the objective for the changing of the diaphragms, and it is not convenient to have a large number of diaphragms. Shade glasses at the focus can be readily changed, but one cannot often obtain exactly the desired amount of absorption. Moreover, no glass can be found which is really neutral.

It was with a view to avoiding such difficulties that plans were made to employ a rotating sectored-disk in the present instrument. There is the great advantage that sectors can be cut so as to reduce the brighter of two objects to almost *exact* equality with the fainter, and thus a variation of either object can be readily detected. The plan was adopted with hesitation because of the fear that the vibration of the disk and driving motor would affect the electrometer thread. Accordingly, a preliminary test was made, using a motor with an eccentric weight on the shaft to produce excessive vibration. It was found that, except at the instant of starting, there was no visible effect on the readings.

Grounding Key. The most frequent operation in the course of observing is the opening or closing of the grounding key. It is therefore important that there be a simple and convenient mechanism for performing this operation. A special advantage is secured if the observer can use the same motion whether opening the key or closing it. Moreover, the mechanism must be positive and make a good contact, but it must work without jarring.

Description of the Photometer and Its Accessories

General Plan. The general plan of the photometer is best perceived from Figure 1, where the instrument is shown on the telescope ready for use.[7] The most conspicuous features are the supporting frame-work, the motor-box *a*, the cell-box *b*, the gimbals *c*, the electrometer *d* and the steadying weights *e*. Comparison with the yard-stick (0.914 meters) on the pier shows the dimensions of the various parts.

Except in the electrometer (which is of brass), aluminum was employed to a large extent, in order to make the weight of the instrument as small as possible; in the picture it is easy to distinguish the aluminum parts because they appear bright in contrast with the other portions. The weight of the photometer as a whole is 99½ pounds (45.1 kilograms).

Top Section. At the top of the supporting frame-work is a circular brass casting called the top plate, which fits over the base plate of the telescope. The top plate is attached to the telescope by 4 studs passing through the lugs *f*. Four steel tubes extend down from the top plate and end in an aluminum casting *g* which is similar in shape to the brass one above. Between the centers of the two plates passes a thin-walled brass tube *h*. This section is really an extension of the telescope rather than a part of the photometer.

Mechanism for Rotation. Under the casting *g* fits another, *i*, which is much like it. These two plates, together with a small brass plate (see Figure 3, *j*) and four clamping screws *k*, constitute the essential parts of the mechanism by which the photometer is rotated. The relations of the parts are shown in Figure 2, which diagrammatically represents a cross-section of the mechanism. From the brass plate *j* there project upward 4 studs, which pass through the plate *g*. To rotate the photometer, one slackens the clamping screws, grasps the lower rods *l* and turns the instrument upon the bearing surfaces *m*, *m*. This construction gives great rigidity because of the wide bearing surface. The knobs *k* have large knurled heads and fine-pitch threads.

Diaphragms. The focal plane of the refractor is about 42 cm. below the base plate. In the focal plane is placed a diaphragm to limit the field and to screen away the light of the sky or of objects near the star under observation. Likewise in the photometry of surfaces, diaphragms are obviously necessary. For convenience, three diaphragms are provided; their apertures are respectively 1/16, 1/8 and ¼ inch (1.6, 3.2, and 6.4 mm.) in diameter. The 6.4 mm. diaphragm remains always in place in the optical axis; the other two are cut in thin strips of brass which can be moved in or out by operating the small knobs *n*, Figure 1.

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[7] Except that in Figure 1 the conduit between cell-box and electrometer is not covered with the rubber sheath which is necessary in practice.

Setting Eyepiece. For setting purposes, means must be provided for viewing the diaphragm, together with the object whose light may be focussed there. In Figure 1, *o* is the diagonal eyepiece used for setting. It is supported by another tube *p* within which it is moved back and forth by a rack and pinion. The eyepiece is frequently used for the purpose of shutting external light away from the cell-box. When the prism is in the tube *q* (Figure 3), all light coming through the telescope is totally reflected out through *o*.

Motor, Sectored-Disks, and Safety Switch. Immediately above the diaphragm is the position for the sectored disks. The relative positions of disk, motor and diaphragm can be seen best in Figure 3. This picture shows how the motor is pulled out and supported when the disk is to be changed. The clamping nut *r*, which holds the disk, can be readily loosened with the fingers. *s* is the handle which is grasped in pulling out the motor; it serves also in opening or securely closing the motor-box, by operating the locking-pin *t*. It is of interest to note the shape of the edges of the motor-box. This light-tight form of construction is used wherever necessary throughout the instrument.

In order to lessen vibration, the speed of the motor was regulated to about 1000 R.P.M. by means of resistance coils. A number of other precautions were taken to diminish the vibration: the motor was fastened down upon pads of felt; care was taken to see that the bearings were properly fitted, and special oil-cups were provided; the disks were carefully balanced, equal sectors being cut from exactly opposite sides.

u (Figure 1) is the switch for the motor, and *v* is a safety switch. Suppose the observer turns off the current at *u*, thus stopping the disk in order to let through the uninterrupted light of a star. He then grasps the knob *w* (Figure 3) and pushes it upward until hte leather disk *x* (Figure 4) is in contact with the nut *r*. By turning *w* the sectored disk is turned until the open part comes opposite the diaphragm. Then a catch clicks into a small depression in the disk. Figure 4 (1), is a diagrammatic cross-section showing the relative positions of the various parts. Figure 4 (2), is a diagrammatic view from above; in dotted lines is shown the position of the catch when it is turned up horizontally out of the way of the disk. Damage might be done if the motor were started in rotation while the catch was still holding the disk; hence the safety switch *v*. It is seen from Figure 4 that the catch is directly connected with *v*. When the catch is turned down to engage in the disk, *v* is "Off." When the catch is turned up away from the disk, *v* is "On." Thus the motor cannot be started unless the catch is out. I have found, however, that when using sectors of large aperture (viz., ¼, ½ or 1 mag.) it is seldom necessary to use the catch. Having finished a group of readings on the brighter star, I stop the motor by turning the switch *u* and rack in the setting eyepiece. By the time the latter operation is finished, the disk has come to rest. A glance into the eyepiece shows whether the occulting portion of the disk is in front of the diaphragm. If so, the knob *w* is turned until the star again flashes into view. With a moonlit sky, it is not necessary to keep the telescope on the previously observed star while setting the disk; the sky background is plainly visible in the eyepiece unless the disk happens to be in the way.

Focussing Mechanism. It would be very convenient if the photometer were attached to a tail piece of the telescope which could be moved up and down in the optical axis, thus focussing the photometer as a whole. Since the Lick 12-inch refractor is not thus equipped, other means of focussing must be adopted. For setting purposes it is essential that one be able to bring both star and diaphragm to focus in the eyepiece. Also, one sometimes (when working with a small diaphragm) wishes to put it out of the visual focus by a definite amount, so as to make sure that all the violet light is admitted. At the same time it is desirable that the relative positions of diaphragm, eyepiece and disk be kept always the same. A plan was considered for making the whole photometer (including cell-box and electrometer) move together with the motor-box. But that plan was discarded in favor of the simpler and easier one of moving motor-box alone. The mechanism for focussing is the familiar one frequently employed in astronomical instruments. The tube which projects upward from the motor-box is provided with an external thread; this thread engages in the internal thread of a collar to which is attached the focussing wheel, Figure 3, *y*. The collar is suspended from the casting *i* (Fig. 1) just above in such a way that it can rotate freely. Turning the focussing wheel causes the upper tube of the motor-box to travel up into the collar or down out of it, according to the direction of rotation.

The Cell-Box and Its Contents. The cell-box is made mostly of aluminum. The front and back sides consist of sliding doors which are instantly removable and afford easy access to the box. In Figure 3 the box is shown with both doors removed; the ends have been taken off, too, for this picture; *z*, *z* are tubes cast into the frame-work. Through each tube passes one of the supporting rods *l* (Fig. 1). The latter have long threads so that the box can be moved vertically if desired. Since the cell-box and motor-box are movable separately the tube connecting them must be made to fit that condition. This is accomplished by using telescoping tubes at A. There is an advantage in making the cell-box readily detachable, because it not infrequently happens that one wishes to work with cell-box and electrometer alone. It is necessary merely to give several turns to the lowest section of the tube A, thus unscrewing tube from cell-box, and then to take off the four nuts B.

In Figure 3 is shown the quartz photo-electric cell C. It is necessary that the cell be supported in such a way that its position can be changed readily in any or all of the three coördinates; hence the system of rods and clamps, whose relations are obvious from the picture. A rigid bar connects the two uprights so that there is no danger of possibly moving the one upright more than the other and thus throwing a strain upon the cell. But since the uprights must be movable independently so as to increase or decrease the distance between them[8] the connecting bar is made of two parts which telescope.

To the cathode of the cell is attached a fine platinum wire which passes down through the bottom of the cell-box and through a flexible conduit until it joins the thread of the electrometer. Means must be provided for touching this connection so as to discharge the electrometer thread or to charge it to a known potential. E is the standard supporting the contact point, which appears in the picture as a small round dot. Between the brass standard E and the contact point there is an insulating disk of amber. F is the arm which moves up to make contact. Both of the contact points are tipped with platinum. Figure 5 shows the mechanism by which the grounding key is operated. G is a string pulled by the observer. Each time the string pulls down the arm from which it is suspended, the ratchet wheel H advances by one notch ($=1/8$ of a revolution). H is rigidly connected to the same axis as the cam wheel I; when H advances 1/8 revolution, I also advances 1/8 revolution. Thus the finger J successively falls into one of the depressions or rises upon one of the blades of the cam wheel. J is connected to the rod K and its motion causes K to rotate slightly. To the middle of K is connected an arm (see Figure 3, F). As K rotates back and forth, the arm F successively comes down to touch the contact point and moves back about 4 cm. from contact. For Figure 5 the photo-electric cell has been displaced to the right from its usual position in order not to obstruct the view of the grounding mechanism.

Two wires (one to the grounding key and the other to the anode of the cell) enter the cell-box through the tube M (Figure 3). This same aperture admits dry air; the dry-air tube N joins an extension of M not visible in the picture. O is a thin piece of optical glass which seals the box nearly air-tight. This glass is mounted in such a way that it can be readily removed if necessary.

Gimbals and Flexible Conduit. Figure 3 shows the gimbal rings c which are necessary in order that the electrometer may hang always vertical. The gimbals are provided throughout with ball-bearings as a precaution against zero-shift.

Q is a flexible coil spring which conducts the platinum lead between cell-box and electrometer. In practice this conduit is kept covered with a rubber sheath to keep out dust and moisture. But while these pictures were being taken the sheath was removed in order to show clearly the construction of the conduit. Inside the spring, at intervals of about four cms., there are amber disks which support and insulate the platinum wire. Each amber piece is mounted in a metal cell which has an external thread of the same pitch as the spring; by means of a special driver these cells were screwed along the spring to the proper places.

Electrometer. Since the electrometer is of standard type and the main features are well known, it is not necessary here to give more than a brief description of the instrument. It consists essentially of a fine platinum wire (called generally the "thread") which is stretched vertically and parallel to two equidistant knife edges. One of these knives is charged positively, the other negatively, and the suspension is connected to ground. If the ground connection is broken the thread is free to pick up a charge and it will drift toward one knife or the other according to the sign of the charge acquired. There are means for changing the tension of the suspension by minute amounts, for adjusting the knife-edges to parallelism, for moving each knife in or out by small distances, and for adjusting the microscope.

In Figures 6 and 7 are exhibited the various parts mentioned above. For Figure 6 the outside case of the electrometer has been removed, and the slide drawn up. In Figure 7 half of the case is pulled back and the side of the microscope is removed to disclose the optical system. R is the bracket which supports the microscope objective; S is the handle of the screw for focussing the objective by sliding the bracket R. In Figure 6 the nose of the objective can be seen behind the knife-edges. T, T are total-reflection prisms; they are mounted on brackets which can be slid backward or forward on smooth, dove-tail ways. The scale of the microscope is in the common focal plane of objective and eyepiece. U is an electric lamp for illuminating the thread and the scale; V (Fig. 6) is the ground-glass window which admits the illumination; W is the capstan-headed screw which is turned in order to change the tension on the suspension. X, X are the micrometer heads which are turned to move the knives in and out; Y, Y are adjusting screws for setting the knives vertical and parallel. Z (Fig. 7) is a clamp for the microscope; the latter can be moved slightly in the horizontal direction (cf. p. 109) when this clamp (and some other screws) are loosened. α (Fig. 6) is a tube containing metallic sodium, for keeping the inside of the electrometer dry; β (Fig. 7) is a tube for admitting dry air; but in practice this tube is kept closed and sodium alone is used.

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[8] For instance, such an adjustment would be necessary in order to exchange the cell shown here for one of different size.

The whole electrometer is covered with a jacket made of half-inch felt, the purpose of which is to protect the instrument from temperature changes; δ (Fig. 1) and η (Fig. 7) are corresponding caps in the felt jacket and in the metal case. Both caps can be turned back without disturbing the rest of the jacket and case, thus affording easy access to the micrometer head, X (Fig. 6). Similarly, the felt cap θ (Fig. 1) and the door λ (Fig. 7) can be opened to provide access to the capstan screw W. μ is a handle which is grasped for unscrewing the weight-rod from the bottom of the electrometer. ξ is the clamp of the temperature compensation; changing the position of this clamp alters the proportions of brass and nickel-steel in the suspension (cf. p. 109). The Wollaston wire at present in the suspension is .0015 mm. in diameter. Unexpected difficulties were encountered while putting in this suspension and experiment showed that the trouble was due to faulty methods of etching off the silver. The procedure which was finally adopted is given below for the benefit of other persons who may encounter similar difficulties.

The wire is cut to the proper length and the ends are soldered into two small brass pieces. By means of these end pieces, the wire is held straight in the clamp. Now beeswax is spread carefully over clamp, brass end-pieces, and a little of the wire at each end. All liquids are gently and slowly siphoned into and out of the vessel containing the wire. Distilled water is used in all solutions. First mix a solution consisting of nitric acid about 12 parts, water 100 parts, sodium nitrite 1 part; allow the wire to remain in this solution until it is seen that the silver has mostly been dissolved, then wash with a strong solution of potassium dichromate; wash next with a 50 per cent solution of ammonia, and lastly with distilled water.

The paragraph above embodies not only my own experiments but also the conclusions which the staff and the mechanicians of the Physics Department have arrived at more recently in the course of putting the suspension into their new electrometer. In preparing the suspension for the Lick Observatory electrometer, no use was made of potassium dichromate or of sodium nitrite; but there are advantages in the more lengthy process recommended here.

A description of the electrometer is not complete without special acknowledgement to Mr. W. R. Stamper for the excellence of his work on this instrument. It has proved to be highly satisfactory in every respect.

Sensitivity Switch. Mention has been made above of the fact that the sensitivity of the electrometer thread is measured by charging it to a known potential and noting the resulting deflection. In Figure 7, Φ is the sensitivity switch. The lowest of the three terminals is connected to the grounding key in the cell-box. Of the upper terminals, one is connected to ground and the other to the positive pole of the sensitivity cell.

Batteries. As has been mentioned above, the potentials for the photo-electric cell and the electrometer are furnished by dry-batteries. The kind used are the small three-cell units used in flashlights. These batteries are placed end to end and the successive terminals soldered together. Two different methods have been employed for preserving the batteries. One method is to place them in a shallow box, solder the terminals and then pour in melted paraffine sufficient to cover all but the terminals. The other method is to shellac the batteries, place them in a glass-lined box, and separate each from its neighbor by interposing strips of glass. These two methods appear to be about equally efficient. With the second one there is the advantage that it is not necessary to solder the connections, a tightly twisted wire being sufficient. Moreover, in the second method it is easy to remove a battery which has "gone bad" and to replace it with a new one.

Dry-Air System. Compressed air from a storage tank escapes slowly through a valve, bubbles through a U-tube containing sulphuric acid and from there is conveyed by rubber tubing to the cell-box.

Photo-Electric Cell. The fundamental necessity in work of this kind is to have a good photo-electric cell; it should be as sensitive as possible, give photo-currents strictly proportional to the light-intensity (at least within the range used) and be free from large or inconstant dark-currents. Professor Jakob Kunz has described[9] his methods of constructing cells which in general fulfill these requirements, though there is wide divergence in the performance of different cells even if made at the same time under apparently identical conditions. If the material of the cell-wall be fused quartz, dark-currents are greatly diminished. Also, quartz cells are more sensitive than those made of glass. Professor Kunz kindly supplied both a quartz and a glass cell for use in this photometer. Each is argon-filled and has a sensitive surface of potassium-hydride.

Stop-Watch. All measures with the electrometer consist in noting the time required for the thread to traverse a given number of scale divisions. For this purpose a stop-watch is employed. Other observers have found it a problem to obtain a watch which will stand up under constant use. I have experienced no difficulty in that respect. The watch used is a "17 jewel Standard," made by the Standard Watch Co., New York; it has given excellent service for more than a year.

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[9] *Phys. Rev.* **7**, 62, 1916.

Tests and Adjustments

Characteristic Curves of the Photo-Electric Cells. Before a photo-electric cell can be used, its characteristic curve must be determined. The illumination is kept constant while the potential across the cell is varied; the rate of charging changes at first slowly, then more rapidly until the "danger point" is reached. Beyond this point the voltage cannot be increased for fear of "flashing" the cell. A safe rule is to stop when the addition of 4 volts doubles the rate of charging. In the work described below, the two cells belonging to the observatory are designated as G II and Q—the former being the glass, the latter, the quartz cell. Besides these there was at hand a glass cell belonging to the Physics Department, which is designated as G I.

TABLE I

Comparison of Characteristic Curves
(points read from smooth curves)

Volts on Cell	Rate of Charging $\left(\frac{\text{volts}}{\text{sec}}\right)$			
	G I	G II	Q	Q/G II
0	.00	.00	.00	
5	.01	.00	.005	
10	.01	.005	.010	2.0
15	.02	.005	.010	2.0
20	.02	.005	.010	2.0
25	.02	.005	.010	2.0
30	.02	.005	.015	3.0
35	.03	.010	.020	2.0
40	.04	.010	.020	2.0
45	.04	.010	.025	2.5
50	.04	.010	.025	2.5
55	.04	.010	.030	3.0
60	.05	.015	.035	2.3
65	.05	.015	.040	2.7
70	.05	.020	.045	2.2
75	.06	.020	.050	2.5
80	.07	.020	.060	3.0
85	.08	.025	.070	2.8
90	.09	.030	.075	2.5
95	.10	.040	.080	2.1
100	.11	.045	.095	2.1
105	.13	.050	.105	2.1
110	.14	.065	.120	1.8
115	.16	.080	.140	1.8
120	.18	.095	.165	1.7
125	.20	.115	.195	1.7
130	.22	.140	.240	1.7
135	.24	.160	.290	1.8
140	.26	.190	.340	1.8
145	.29	.230	.400	1.7
150	.31	.265	.455	1.7
155	.35	.315	.515	1.6
160	.38	.390	.590	1.5
165	.43	.470	.670	1.4
170	.50	.580	.785	1.4
175	.58	.700	1.000	1.4
180	.67	.825	1.280	1.6
185	.79	.970	1.770	1.8
190	1.00	1.250	2.080	1.7
195	1.24	1.860	2.330	1.3
200	1.82	2.990		
				Mean, 2.2

First, characteristic curves were derived for each of the three cells; the results are given in Table I and Figure 8. In each case the illumination was about equivalent to that of an object of −4.1 magnitude (i.e. about 110 times a first-magnitude star) as seen through the 12-inch telescope. It is seen from Figure 8 that, except for the highest voltages, the curves for G II and Q are similar in shape, the ordinate of Q being almost constantly two times that of G II. But G I has a curve markedly differing in shape from the other two. All three cells were made by Professor Kunz and are of practically identical pattern; but G I is about four years older than the others.

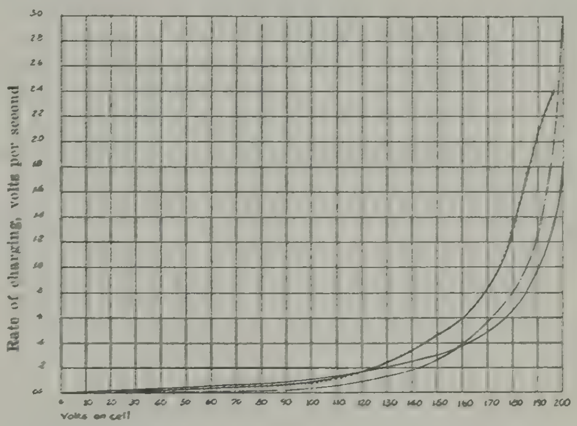

Fig. 8. Characteristic curves of 3 potassium-argon cells.

——— G I. Glass cell I. (belonging to the Physics Dept. of the U. of C.).

——— G II. Glass cell II. (belonging to the Lick Observatory).

——— Q Quartz cell (belonging to the Lick Observatory).

Comparison of the characteristic curves for G II and Q exhibits the superiority of the quartz cell, which for any given voltage is about twice as sensitive as G II. Moreover the glass cell has reached the danger point at about 195 volts, while an increased voltage (with consequent increase in sensitiveness) can safely be applied to Q. A further important advantage of the quartz cell is that the dark-current is vanishingly small, while for the glass cell there is a large dark-current. I therefore decided to discontinue the tests of the glass cell.

A further study of the quartz cell was next made, to determine the characteristic curves under different degrees of illumination. Although I found no published account of a similar investigation, I expected that changing the amount of incident light (say, reducing it one-half) would merely result in multiplying each ordinate by the same factor. The two curves would thus have similar shape although in the second case a slightly higher voltage could be applied before the danger point was reached. These expectations (except, of course, the latter) were not fulfilled, as can be seen by an examination of Figures 9 and 10. In the second part of Table II is given a comparison of the several curves. It is evident that the curves cannot be fitted together by applying any simple factors.

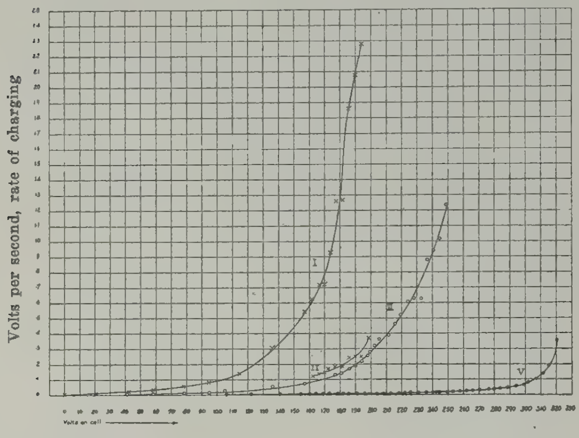

Fig. 9. Characteristic curves of quartz cell under various illuminations.

I. Light equivalent to a star of *minus* 4.1 magnitude, as viewed through the 12-inch refractor.

III. Light equivalent to a star of *minus* 1.7 magnitude.

V. Light equivalent to a star of *plus* 3.0 magnitude.

Figures 9 and 10 are significant in their relation to the question of what voltage should be applied when the cell is used for stellar photometry. Obviously, the voltage can be much greater for the fainter stars. The following rule has been adopted: for observing stars of third magnitude and fainter, put 300 to 310 volts across the cell; for stars of 1.0 magnitude and fainter, 240 to 260 volts; for stars brighter than 1.0 magnitude, 200 volts or less.

In studying this subject further, it will be of interest to see whether similar results are found for the glass cell, and to use an even wider range of intensities for the quartz cell. With the latter it seems likely that characteristic curves with illuminations equivalent to fifth or sixth magnitude stars would indicate the advisability of using potentials higher than 310 volts in observing these fainter stars.

Illumination-Current Proportionality. It is a very important matter to determine what are the qualities of a cell in regard to illumination-current proportionality; its value and convenience as a photometric instrument are greatly increased if it shows strict linear proportionality. Different experimenters[10] have found various results. Elster and Geitel made measures with their cells over a wide range of intensities and concluded that the relation is strictly linear. Guthnick and Prager[11] found that two Elster and Geitel cells (one of sodium, the other of rubidium) showed linear proportionality through a range of 2½ magnitudes. Kunz[12] used a number of methods to test the cells made by him. He concluded that if the incident illumination is weak the cells show linear proportionality, and that they are therefore sufficiently accurate for stellar photometry. He found, however, that for large illuminations (greater

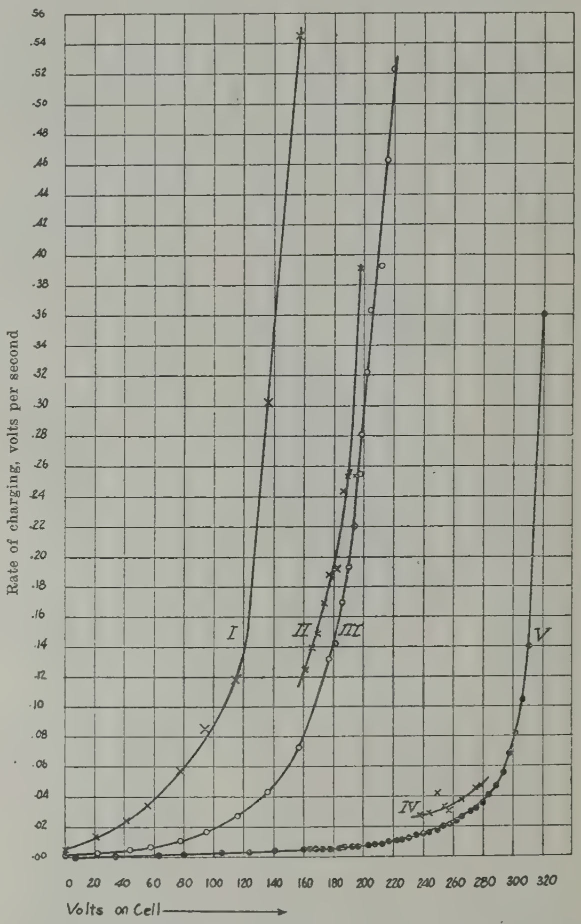

Fig. 10. Characteristic curves of the quartz cell under various illuminations. (Drawn with large vertical scale in order to show accurately the lower part of each curve.)

I. Light equivalent to a star of *minus* 4.1 magnitude, as viewed through the 12-inch refractor.

III. Light equivalent to a star of *minus* 1.7 magnitude.

V. Light equivalent to a star of *plus* 3.0 magnitude.

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[10] Griffith, *Phil. Mag.* (6) **14**, 297, 1907.
Elster and Geitel, *Phys. Zeitschr.* **14**, 741, 1913.
Ives, *Ap. Jour.* **39**, 428, 1914; **43**, 9, 1916.

[11] *Veröffent. Berlin-Babelsberg*, **1**, part 1, p. 18.

[12] *Ap. Jour.* **45**, 69, 1916.

than are obtained from stars) there are deviations from a straight line. Coblentz[13] after investigating about a dozen photo-electric cells, concludes that "if the deflections method is to be used,—the proportionality test should be made upon every cell—even when the maker's tests indicate that the cell functions in direct proportionality."

In the physics laboratory at Berkeley, a few measures were made of the cell G I, using a galvanometer to measure the current; the illumination was varied by an adjustable sectored-disk, also by altering the distance between lamp and cell. G I was found to show strict linear proportionality within a range of intensities from about 1 to 0.04 candle-meters.

The proportionality of the quartz cell was tested at the observatory. The cell-box and the electrometer were set up at the end of a long gallery; upon a table, which could be wheeled back and forth along a track, was set a small lamp which was fed by current from a storage battery and this lamp was enclosed so that reflection from the walls of the gallery would not produce erroneous effects at the cell. In order to guard against errors which would result from a progressive change in the lamp or in the sensitiveness of the cell, I generally varied the distance in no regular way but moved the light back and forth so that a particular part of the curve was observed at different times in the course of one series of measures. After finishing one series, I varied the intensity of the lamp by changing the current and then took another series of measures with the same procedure. The smallest distance used was 58 inches (1.5 meters) and the greatest was 457 inches (11.6 meters).

Table III contains the results of the investigation. The separate values are given in order of increasing light intensity. The first column gives the value of $1/D^2$. For convenience in making the table, the values of $1/D^2$ throughout are multiplied by 10^5. For instance in the case of the first tabulated value, the distance was 456.8 inches and the logarithm of $1/D^2$ is $4.6806-10$.

If the points of Table III (exclusive of those enclosed in brackets) are plotted with $1/D^2$ as abscissae and volts/sec. as ordinates, they are found to define accurately a series of straight lines passing through the origin. The slope of the particular line depends upon the intensity of the light, since varying the absolute brightness of the lamp in a certain ratio has the effect of changing the vertical scale by that same amount. Thus on September 19 the light for the third series was 2.43 times as bright as that for the first series. Since on the three dates all conditions of observing were the

TABLE II

CHARACTERISTIC CURVES OF QUARTZ CELL UNDER VARIOUS ILLUMINATIONS

Volts on cell	Rate of charging $\left(\frac{\text{volts}}{\text{sec.}}\right)$ (points read from smooth curves)					Ratios				
	I	II	III	IV	V	I/II	I/III	II/III	III/V	IV/V
0					.000					
10	.009		.002		.000		4.5			
20	.013		.003		.000		4.3			
30	.017		.004		.000	4.5	4.2			
40	.023		.004		.000		5.8			
50	.029		.006		.000		4.8			
60	.038		.007		.000		5.4			
70	.047		.009		.001		5.2		9.0	
80	.060		.011		.002		5.5		5.5	
90	.076		.014		.002		5.4		7.0	
100	.097		.018		.002		5.4		9.0	
110	.122		.024		.002		5.1		12.0	
120	.172		.030		.003		5.7		10.0	
130	.252		.037		.003		6.8		12.3	
140	.324		.047		.004		6.9		11.8	
150	.410		.061		.004		6.7		15.2	
160	.580	.122	.078		.005	4.8	7.4	1.6	15.6	
170	.780	.152	.106		.005	5.1	7.4	1.5	21.2	
180	1.270	.191	.139		.006	6.6	9.1	1.4	23.2	
190	2.075	.250	.192		.007	8.3	10.8	1.3	29.4	
200		.400	.280		.008			1.4	35.0	
210			.396		.009				44.0	
220			.510		.010				51.0	
230			.675		.013				51.9	
240			.920	.028	.015				61.3	1.9
250			1.245	.031	.018				69.2	1.7
260				.035	.023					1.5
270				.041	.029					1.4
280				.052	.036					1.4
290										

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[13] *Sci. Papers Bur. of Stand.* No. 319, 1918.

same and the same potentials were maintained at the anode, it is reasonable to assume that the sensitiveness of the cell was practically the same for all the measures in the table and that one may safely compare any two series of points. Thus it is seen that the brightest light used was for the third series of September 19; and this was about 490 times as intense as the faintest light, which was that for the second series on September 23.

The straight line relation does not hold, however, when the rate of charging becomes relatively very large; this is seen by examination of the points included in brackets. The deviation is marked and always in the same direction, namely; the increase in the current is too rapid in proportion to the increase in $1/D^2$. Within the limits of illumination where the cell was observed to show linear proportionality, the maximum rate of charging was 1.54 volts per second. This is about what is produced by a star of 0.8 magnitude when the cell is mounted in the photometer on the 12-inch refractor, with 300 volts at the anode. The minimum rate was

TABLE III

Measures for Determining the Illumination-Current Relation for the Quartz Cell

Relative intensity $1/D^2$	Rate of charging volts/sec
1920 September 19	
1st series	
.48	0.090
.60	.110
.82	.160
1.21	.241
1.99	.405
2nd series	
3.85	.691
4.21	.735
8.53	1.682
10.41	2.233
3rd series	
.37	.180
.41	.200
.52	.241
.56	.261
.58	.279
.68	.331
.78	.380
.86	.337
.98	.479
1.14	.519
1.34	.616
1.55	.764
1.89	.958
2.37	1.208
3.09	1.576
3.91	2.040
5.41	3.124
4th series	
1.53	0.181
1.89	.240
2.39	.300
3.36	.430
3.79	.522
4.54	.618
5.45	.747
6.50	.961
8.73	1.304
10.47	1.539
13.36	2.050
17.78	2.862
23.13	3.897
1920 September 19—(*Cont.*)	
5th series	
.37	0.037
.49	.038
.56	.047
.65	.045
.78	.071
.92	.092
1.10	.116
1.29	.130
1920 September 23	
1st series	
17.09	0.030
20.55	.035
23.13	.040
25.20	.044
30.25	.050
2nd series	
19.98	0.019
20.85	.021
23.49	.023
26.66	.028
29.47	.034
3rd series	
3.85	0.709
4.20	.797
4.60	.867
4.94	.949
5.27	1.048
5.55	1.110
5.76	1.258
4th series	
0.83	.180
1.06	.220
1.37	.272
1.67	.329
1.91	.367
2.32	.441
2.75	.536
3.13	.583
3.52	.662
3.85	.734
1920 September 23—(Cont.)	
5th series	
2.28	0.050
2.36	.060
2.67	.060
2.70	.060
3.09	.070
3.61	.080
4.96	.110
6.03	.130
1920 September 27	
1st series	
.87	0.140
1.06	.155
1.22	.161
1.38	.180
1.59	.239
1.80	.270
2.02	.300
2.26	.339
2.64	.396
3.04	.458
3.43	.514
3.82	.589
4.19	.644
4.36	.663
4.53	.684
4.77	.773
5.05	.823
5.33	.906
5.43	1.005
5.59	1.080
5.72	1.154
5.83	1.189
1920 September 27—(Cont.)	
2nd series	
.86	0.120
.90	.130
1.04	.130
1.21	.160
1.39	.180
1.61	.211
1.85	.241
2.11	.271
2.25	.291
2.40	.323
2.73	.356
3.31	.435
3.73	.488
4.08	.539
4.44	.575
4.53	.599
4.74	.616
4.86	.646
5.08	.675
3rd series	
2.91	0.345
3.43	.398
4.02	.477
4.46	.536
4.94	.584
5.35	.640
5.74	.672
6.13	.728
6.72	.794
7.18	.856
7.94	.932
8.15	.967
8.98	1.082
9.71	1.215
10.52	1.386
11.08	1.610

0.019 volts/sec., about what is produced by a 6th magnitude star under the same conditions. It is evident, therefore, that when the incident light is of the same order as that found ordinarily in stellar photometry, the photo-currents are proportional to the illumination over a wide range. The deviations from this rule for lights brighter than a star of 0.8 magnitude need give no concern in the case of the present photometer, because in practice one always cuts down the light of such bright objects by means of a sectored disk. The conclusion stated here is in agreement with that of Kunz,[14] and the deviation for large intensities is in the same direction as was observed by him.

Adjustment of the Electrometer. The first step in adjusting the electrometer was to set the knives parallel by means of the screws provided for this purpose. Then the clamping screws for the microscope were loosened and the latter was moved slightly until the thread appeared in the field of view near the zero division, following which the clamping screws were securely tightened again.

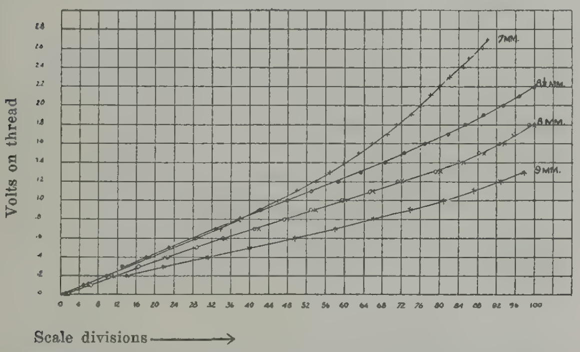

Fig. 11. Curves showing the variation of the Electrometer field as the distance between the knives is changed.

The next step was to set the knives at such a distance apart that the field between them was uniform over the space included in the microscope field. For testing the electrostatic field one varies by minute known amounts, the potential on the thread, and notes how many scale divisions of deflection result from applying each potential. A potentiometer circuit used with a storage battery furnished the small potentials required. When the results are plotted with deflections as abscissae and applied potentials as ordinates, the curve should be a straight line if the field is uniform. In Figure 11 are given a few of the curves. In each case the potential between the knives was 80 volts, but the tightness of the thread was varied so as to bring the curves a convenient distance apart. With each curve is given the distance between the knives. It is seen that as the distance increases the field becomes more uniform. As a consequence of these tests the rule was adopted that 8½ mm. between the knives should be the minimum distance, and the usual distance is 9 to 12 mm.

It was necesary to determine by experiment the best position for the temperature compensation clamp. The method employed for changing the temperature was to pump hot or cold air into the outer case of the electrometer. The electrometer was wrapped heavily in flannel to minimize losses by radiation; a thermometer was put inside the case in such a way that it could be withdrawn readily for reading. As the temperature changed the sensitivity of the thread was read at frequent intervals. The sensitivity changes were rapid at first, but became less as the electrometer approached a uniform temperature. At last a steady condition was reached, when the entering air no longer changed the temperature, and the sensitivity remained constant. Next the temperature was changed again (by making the incident air colder or warmer) until another steady condition was reached. The first experiment gave as equilibrium positions:

Temperature 18 deg. C,	Sens. 65.0 div./volt
22	50.5
24	44.0
23	44.8
27	25.5

The clamp of the compensation was about 11.9 mm. from the top of its range.

From the above figures it is seen that with increasing temperature the suspension expands by too small an amount. Accordingly the proportion of brass was increased by moving the clamp down 13 mm. and the experiments were repeated. This time the temperature-sensitivity curve observed between 19 degrees and 30 degrees C. was found to be nearly horizontal, and so the compensation clamp was not moved further. In practice the temperature compensation has functioned satisfactorily.

Other Adjustments. When the photometer was first put on the telescope, difficulty was experienced with dark-currents and leakage effects. These factors did not cause any difficulty during the dry season, but when the humidity is high they are sometimes present to a considerable amount.[15] Evidently, then, they are due to the accumulation of moisture upon some of the surfaces. Plans have been considered for making the cell-box more nearly air-tight, and for improving the method of drying the air.

For a while trouble was experienced with contact potentials at the grounding key and the sensitivity switch. The trouble persisted in spite of repeated scrubbing of the contact points with "non-beverage grain alcohol." Then chemically pure alcohol was employed with the result of removing the contact P. D.

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[14] *Ap. Jour.* **45**, 75, 1917.

[15] It should be added that always after light has fallen on the cell there will be a residual dark-current which gradually fades away. One test showed that, with 245 volts across the cell, the dark-current 30 seconds after exposure to a 4.0 magnitude star was about 2 per cent. of the star effect, or equivalent to that produced by an 8.2 magnitude star.

PROCEDURE IN OBSERVING

Preliminary. Precautions must be taken to insure that the photometer has settled down to a steady condition before one begins observing. For one thing, if the sensitivity of the electrometer thread is changing rapidly during the measures, an amount of uncertainty is introduced and there will be large zero-shifts. The change of sensitivity is rapid for some time after the electrometer lamp is lighted. This is due to the fact that the lamp heats the electrometer slightly, causing an expansion of the parts, and a steady condition is not reached for some time. For this reason the observer lights the electrometer lamp an hour or more before beginning the observations, and he opens the dome for a similar reason.

About one-half hour before observations are begun the potentials are applied to the electrometer knives and to the photo-electric cell. The potentials fluctuate slightly at first and do not steady down until 15 minutes or more after the connections are made.

It is necessary to illuminate the cell for several minutes before beginning to take measures; otherwise it is found that the first measures are inaccurate. One begins at twilight to allow enough skylight to fall on the cell so that an effect is produced which is about equivalent to that of a third magnitude star. The amount of skylight is controlled by the position of the diagonal eyepiece; as the skylight fades, a larger and larger aperture is opened. The above is the procedure if one is to begin observing as soon as the sky is free from daylight. If one begins later in the night, a star is used for the purpose. The preliminary illumination need not last more than half an hour and generally not longer than 15 or 20 minutes. The observer takes test measures, beginning soon after the illumination is applied. At first the rate obtained is too small, sometimes by as much as 50 per cent. Gradually the rate increases until it reaches a steady value; then one can begin making measures.

Measures of Sensitivity and Zero-Shift. The observation of the sensitivity consists in bringing the electrometer thread to ground potential, then (by use of the sensitivity switch) charging it to +1.5 volts, and noting the change in its position on the scale. I generally worked with a potential difference of 100 to 130 volts between the knives, and adjusted the tightness of the thread so that the sensitivity was about 54 div./volt. But when there was wind sufficient to shake the telescope, it was necessary to tighten the thread to 30 div./volt or less.

The sensitivity is measured with greater or less frequency depending on how rapidly it is changing. As a rule the measure is made about every half hour. These sensitivity measures serve also to determine the zero-shift. (cf. p. 112.)

Measures of Dark-Current, Background, and Leakage. At intervals during the night's work measures are made of dark-current, background, and leakage.

Dark-current is so-called because it flows even when no light falls on the cell. This drift is superposed on every deflection measured and a correction must be applied for it. The measurement of dark-current consists in shutting all light away from the cell and then measuring the rate of drift.

Background is the deflection caused by skylight which is unavoidably measured with the star light. This current becomes largest on moonlit nights, particularly if there is much moisture in the atmosphere. The observation of background consists in putting the star image slightly off the diaphragm aperture and measuring the drift of the thread due to sky-light alone.

The measurement of leakage consists in shutting all light away from the cell, giving the thread a potential from the sensitivity cell and observing the rate at which it loses its charge. In dry weather the leakage is nearly always negligible.

Battery Tests. Sometimes the thread is seen to jump suddenly through two or three divisions. This means the presence of a bad cell in the battery supplying the knife potentials. Interruptions due to this cause are guarded against by testing the individual batteries each evening before beginning work. Naturally, a close watch is kept on the battery supplying the potential at the anode of the photo-electric cell; it is obvious (from Figs. 8 to 10) that serious errors are introduced if this potential fluctuates. Also, the voltage of the sensitivity cell is measured frequently; the slightest evidence of deterioration is a signal for replacing this cell.

METHOD OF REDUCING OBSERVATIONS

Conversion into Δ Magnitude. Explanation of Table IV. Conversion of the observational data is effected by use of the familiar formula

$$\Delta M = \frac{\log A - \log B}{0.4}$$

where A and B are the light intensities of the two stars, and ΔM is their difference of magnitude. The first step in the reduction is to change the observed rates,[16] div./sec, into volts/sec, by multiplying by the values of the sensitivity, volts/div.

A sample block of the reductions is given in Table IV. The stars observed were α and β *Cephei*, on 1921,

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[16] Each "observed rate" is the mean of three or four settings; one setting consists in a measure of the rate of charging of the thread as indicated by the speed of the drift across the scale.

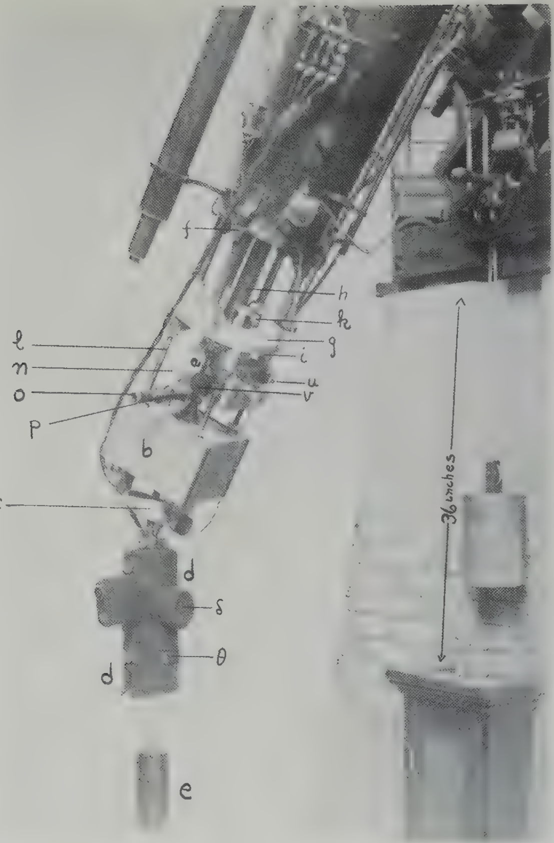

Fig. 1. The Photo-electric Photometer on the telescope ready for use.

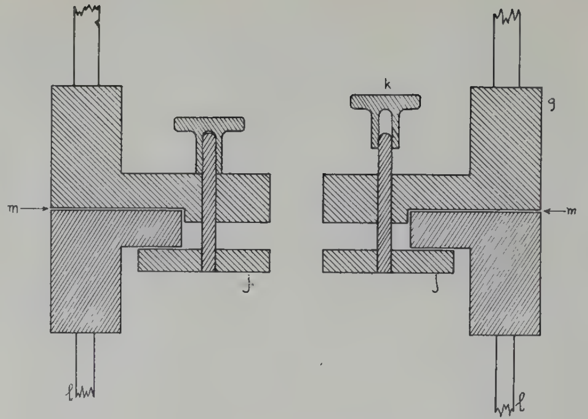

Fig. 2. Diagram of mechanism for rotation.

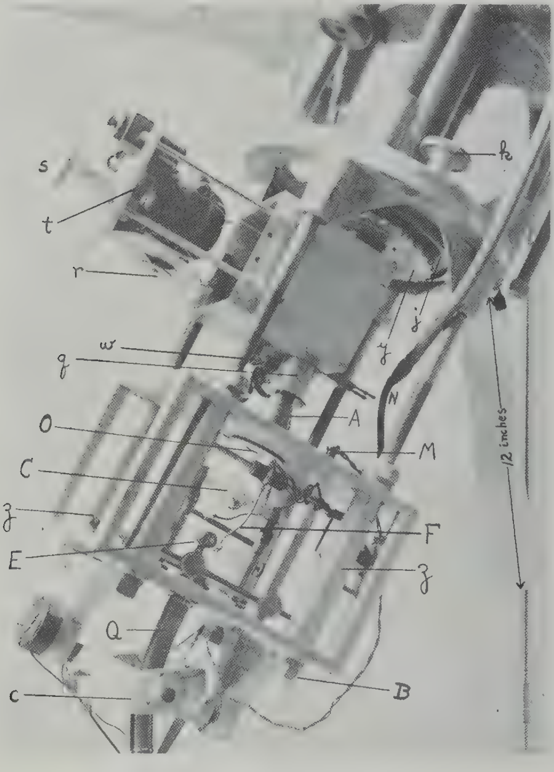

Fig. 3. Disk, motor and diaphragm.

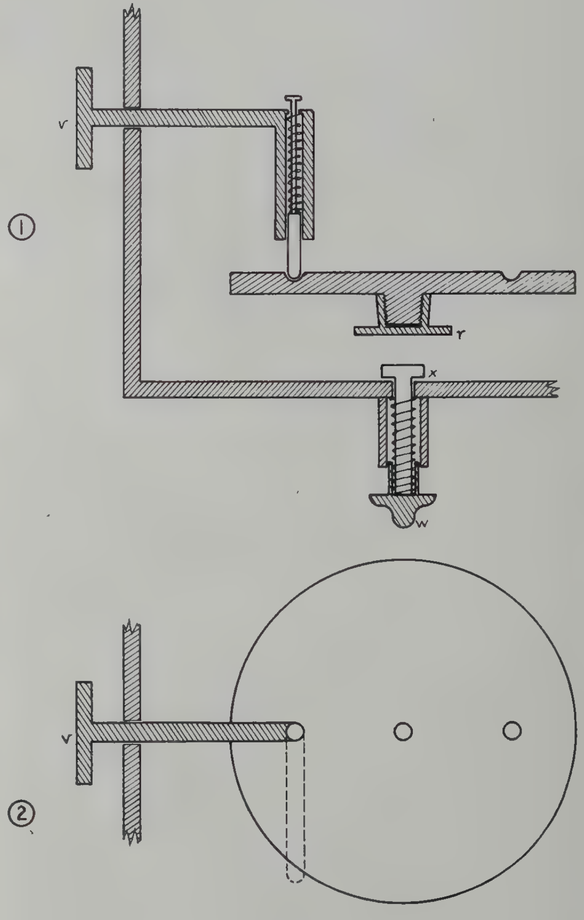

Fig. 4. Diagram of safety switch and catch for sectored disk.

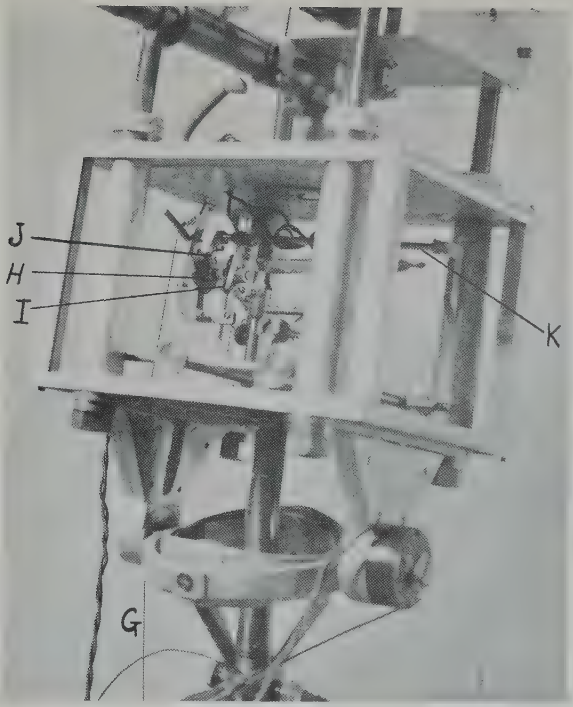

Fig. 5. Mechanism which operates the grounding key.

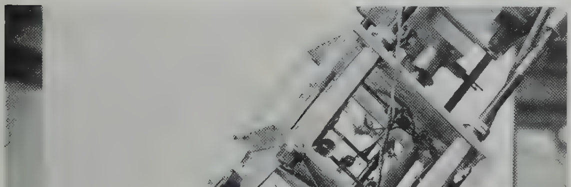

Fig. 6. The Electrometer.

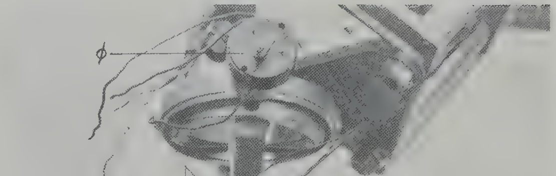

Fig. 7. Side view of electrometer, showing interior of microscope.

TABLE IV

Sample Block of Reductions to Δ Magnitude

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Star	Rate Div.	Sec.	Sens. $\frac{\text{volts}}{\text{div.}}$	log. Sec.	log. $\frac{\text{Div.}}{\text{sec.}}$	log Sens.	log Rate $\frac{\text{volts}}{\text{sec.}}$	Nat. rate	Σ Corr.	Net rate	log R	Sub. 7.7	Δ M	θ	z	Ext.	Δ M +Ext.
																mag.	mag.
α	5	17.4	[.0271]	1.2406	9.4584	8.4330	7.8914	.00779	+ .00002	.00781	7.893	0.193	0.482	$-1^h\ 53^m$	30°.2	.048	0.530
β		17.2	.0271	.2355	.4634		.8964	788		790	.898	.198	.495	2 0	36.4	.081	.576
α		17.4	.0271	.2406	.4584		.8914	779		781	.893	.193	.482	1 43	29.4	.045	.527
β		17.4	.0271	.2406	.4584		.8914	779		781	.893	.193	.482	1 49	35.8	.078	.560
α		17.4	.0271	.2406	.4584		.8914	779		781	.893	.193	.482	1 33	28.6	.042	.524
β		17.1	.0271	.2330	.4660	.4330	.8989	792		794	.900	.200	.500	1 39	35.3	.076	.576
α		17.3	.0272	.2380	.4609	.4346	.8955	786		788	.896	.196	.490	1 24	28.0	.040	.530
β		16.7	.0272	.2227	.4762		.9108	814		816	.912	.212	.530	1 30	34.9	.074	.604
α		17.1	.0272	.2330	.4660		.9005	795		797	.901	.201	.502	1 13	27.3	.038	.540
β		16.9	.0272	.2279	.4711		.9056	805		807	.907	.207	.518	1 19	34.5	.072	.590
α		16.8	[.0272]	.2253	.4737		.9082	810		812	.910	.210	.525	1 03	26.7	.036	.561

August 17. The first column gives the star; the second column gives the number of scale divisions and the time in which this interval was traversed by the thread. Column 3 gives the sensitivity; the bracketed values are observed, the others are interpolated. Columns 4 to 8 contain the computations of the rates in volts per second. To these rates must be applied corrections for dark-current, background, leakage and zero-shift. The corrections are computed on a separate sheet (see Table V) and only their sum is given in the column "Σ Corr." Columns 8 and 9 are added to obtain 10. Frequently Σ Correction = zero, in which case columns 8 to 11 can be omitted. Column 11 gives the logarithm of the net rate; from each of these logarithms is subtracted an amount arbitrarily selected to reduce the size of the number. The amount subtracted is determined from a consideration of the particular computation at hand; a different constant may be used for another series of observations taken on the same night. Through the subtraction of the constant, we obtain the convenient numbers of column 12; multiplying these by 2.5 gives the Δ magnitudes in column 13. These Δ magnitudes are the numerical differences between the stars observed and a fictitious star the logarithm of whose net rate (in the present case) is 7.7. Δ Magnitudes increase numerically with brightness, a convention which is convenient in many cases. The true difference in magnitude between two stars is the same as the numerical difference of their Δ magnitudes, with the sign changed. In column 14 appears the hour-angle. For each star there has previously been drawn a curve with hour angles as abscissae and zenith distances as ordinates. From this curve are read the quantities z in column 15; and from tables for atmospheric extinction (see p. 112) are read the quantities in the 16th column. The addition of columns 16 and 13 gives 17, the final Δ magnitudes.

Corrections for Dark-Current, Background, Zero-Shift, and Leakage. In previous sections explanation has been given of the corrections for dark-current, background, and zero-shift. The leakage correction remains to be discussed. On account of leakage, the measured star-drift is smaller than it would otherwise be; hence the leakage correction always has the + sign. The

TABLE V

Sample Table of Σ Corrections

		Corrections				
Star	Time	Dark current $\frac{\text{volts}}{\text{sec}}$	Background $\frac{\text{volts}}{\text{sec}}$	Leakage $\frac{\text{volts}}{\text{sec}}$	Zero-shift $\frac{\text{volts}}{\text{sec}}$	Σ Corr. $\frac{\text{volts}}{\text{sec}}$
δ	$8^h\ 00^m$	− .00020	− .00008	+ .00001	− .00001	− .00028
γ	05	20	3	1	1	23
δ	10	20	8	1	1	28
γ	15	20	3	1	1	23
δ	20	20	8	1	1	28
γ	25	20	3	1	1	23
δ	30	20	8	1	1	28
γ	40	20	3	1	0	22
δ	45	20	8	1	0	27
γ	50	20	3	1	0	22
δ	55	20	8	1	0	27
γ	$9^h\ 00^m$	20	3	1	0	22

amount of the correction depends upon the number of divisions over which the star-drift has been observed. The rule is to apply the observed leakage multiplied by one-half the proportional part of the scale over which the star-drift was watched. On the night of August 17, when the measures of Table IV were taken, the average leakage was .00055 volts/sec. The number of scale divisions over which the star-drift was measured was 5; the sensitivity was measured over 56 divisions, i.e. the leakage was measured from the 56th division beyond the zero-point. Therefore the leakage correction was

$$\frac{1}{2}\times\frac{5}{56}\times .00055\,\frac{\text{volts}}{\text{sec}} = .00002\,\frac{\text{volts}}{\text{sec}}$$

On the same night dark-current and background were zero, and zero-shift for these particular measures was negligible. Therefore all of Σ Corr. is due to leakage.

The above is a typical example of Σ Corr. There is no case in my observing sheets thus far where all four corrections must be applied. Therefore a hypothetical case is given below to illustrate all of them.

Suppose two stars, γ and δ, are observed in alternation from Pacific Standard Time $8^{\text{h}}00^{\text{m}}$ to $9^{\text{h}}00^{\text{m}}$, at the rate of one star in five minutes. γ is about one magnitude brighter than δ, and is therefore reduced by a sector. The following measures were made for determining the corrections:

At $7^{\text{h}}55^{\text{m}}$, Sens. $= 10.0^{\text{div}} - 90.0^{\text{div}}$, per 1.5 volts
d.c. $= +1^{\text{div}}$ in 90^{sec}
b.g. (without sector) $= +1^{\text{div}}$ in 70^{sec}
leakage $= -1^{\text{div}}$ in 50^{sec}

At $8^{\text{h}}30^{\text{m}}$, Sens. $= 11.0^{\text{div}} - 90.5^{\text{div}}$
d.c. $= +1^{\text{div}}$ in 92^{sec}
b.g. $= +1^{\text{div}}$ in 65^{sec}
leakage $= -2^{\text{div}}$ in 102^{sec}

At $9^{\text{h}}00^{\text{m}}$, Sens. $= 11.2^{\text{div}} - 89.7^{\text{div}}$
d.c. $= +1^{\text{div}}$ in 100^{sec}
b.g. $= +2^{\text{div}}$ in 131^{sec}
leakage $= -2^{\text{div}}$ in 120^{sec}

These measures are combined and reduced as follows:

$$d.c.\left\{\begin{array}{lll} .0111\,\frac{\text{div}}{\text{sec}}, & \text{Sens. } .0188\,\frac{\text{volts}}{\text{div}}; & d.c. = .00021\,\frac{\text{volts}}{\text{sec}} \\ .0109 & .0189 & .00021 \\ .0100 & .0191 & \underline{.00019} \\ & & \text{Mean, } .00020 \end{array}\right.$$

Background is about the same each time; therefore it is assumed to be constant.

$$b.g.\left\{\begin{array}{lll} .0143\,\frac{\text{div}}{\text{sec}}, & \text{Sens. } .0188\,\frac{\text{volts}}{\text{div}}; & b.g. = .00027\,\frac{\text{volts}}{\text{sec}} \\ .0154 & .0189 & .00029 \\ .0153 & .0191 & \underline{.00029} \\ & & \text{Mean, } .00028 \end{array}\right.$$

The difference $.00028 - .00020$ gives the true value of the background, $.00008\,\frac{\text{volts}}{\text{sec}}$. The full amount is applied to each of the measures of star δ; 0.4 of the amount is applied to the measures of γ, because this star was diminished with a one-magnitude sector.

$$\begin{array}{l}\text{leak-}\\\text{age}\end{array}\left\{\begin{array}{lll} .0200\,\frac{\text{div}}{\text{sec}}, & \text{Sens. } .0188\,\frac{\text{volts}}{\text{div}}; & \text{leakage} = .00038\,\frac{\text{volts}}{\text{sec}} \\ .0178 & .0189 & .00033 \\ .0196 & .0191 & \underline{.00037} \\ & & \text{Mean, } .00036 \end{array}\right.$$

The sensitivity was measured over about 89 divisions, on the average; thus the leakage was measured from the 89th division beyond the zero-point. The star-drift was measured over 5 divisions; half the proportional part of the scale is

$$\frac{1}{2}\times\frac{5}{89} = \frac{1}{28}$$

The leakage correction is

$$\frac{1}{28}\times .00036 = .00001\,\frac{\text{volts}}{\text{sec}}$$

$$\begin{array}{l}\text{zero-}\\\text{shift}\end{array}\left\{\begin{array}{l} \text{for measures } 8^{\text{h}}00^{\text{m}} \text{ to } 8^{\text{h}}30^{\text{m}},\ \text{shift} = +1^{\text{div}} \text{ in} \\ \qquad 30^{\text{min}} = .00056\,\frac{\text{div}}{\text{sec}} \\ \text{Mean. Sens.} = .0188\,\frac{\text{volts}}{\text{div}};\ \text{shift} = .00001\,\frac{\text{volts}}{\text{sec}} \\ \text{for measures } 8^{\text{h}}30^{\text{m}} \text{ to } 9^{\text{h}}00^{\text{m}},\ \text{shift} = +0.2^{\text{div}} \text{ in} \\ \qquad 30^{\text{min}} = .00011\,\frac{\text{div}}{\text{sec}} \\ \text{Mean. Sens.} = .0190\,\frac{\text{volts}}{\text{div}};\ \text{shift} = .00000\,\frac{\text{volts}}{\text{sec}} \end{array}\right.$$

The remainder of the computation is given in Table V.

Atmospheric Extinction. No separate investigation of the atmospheric extinction has been made here, and all data on the subject derived to date have been obtained in the course of measures taken for other purposes.

In the reductions for the present paper extinction factors have been used which are based on the work of Guthnick and Prager. First the Mt. Hamilton visual extinction was derived by an interpolation between the Potsdam and Säntis tables.[17] From the visual extinction table are made photo-electric extinction tables for stars of each spectral class, by multiplying by the following factors:

for Class B0	2.0
A0	1.80
F0	1.7
G0	1.54
K0	1.4
Ma	1.3

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[17] Müller, *Photometrie der Gestirne*, Anhang II a.

The above factors are obtained by interpolating in Guthnick and Prager's table,[18] where factors are given for a sodium cell and for a rubidium cell; the values for our potassium cell are assumed to lie between the two. The interpolating factor 0.312 was derived from Shinomya's work.[19] His curves show that, on the average, sodium cells made by Kunz have their maximum sensitiveness at λ 4350; rubidium, at λ 4750; potassium, at λ 4475.

In order to minimize errors introduced by the above process of deriving extinction tables, care was taken not to observe stars at large zenith distances. For *β Cephei* the largest zenith distance for any observation was 44 degrees. In most of the other work a limit of 30 degrees has been set.

It is obvious, from the foregoing discussion, that in selecting two stars to be compared, one should attempt to have them as nearly as possible at the same altitude and of the same spectral class. In practice it is seldom possible to satisfy both of these conditions, and one must make the best compromise possible.

According to Guthnick and Prager, the extinction factors vary with the transparency of the atmosphere. These observers find also that the transparency of the atmosphere for the violet end of the spectrum is least shortly after the end of twilight and increases during the night, but not regularly. Moreover, they find that the extinction varies according to the azimuth. The first of these considerations need give no concern in the case of *β Cephei,* because all the observations of this star were made during the dry season, when the transparency at Mt. Hamilton does not vary appreciably for weeks at a time. On a scale of 3, the transparency on the nights of observation was 2+ or 3 all of the time. As for a variation through the night: I have at times suspected that such a factor entered. But the evidence is not conclusive, and the variations observed here can probably be explained as due to an irregular increase in the sensitiveness of the cell during the course of a night's work. Therefore no attempt has been made to incorporate such a factor in the extinction corrections. Regarding a variation with azimuth, the measures to date give no clear evidence for the existence of such a factor at this observatory.

Method of Combining Measures. One complete observation, comparing two stars *a* and *b* is composed of 20 separate settings in the order *aaaa bbbb aaaa bbbb aaaa*, or 15 settings in the order *aaa bbb aaa bbb aaa*. In the reductions, as in Table IV, each of the rates in the second column of the table consists of the mean of four (or three) settings. If six successive values in the table are numbered $\alpha_1\beta_1\alpha_2\beta_2$ and so on, then the first whole observation consists of $\alpha_1\beta_1\alpha_2\beta_2\alpha_3$ and the second observation consists of $\alpha_3\beta_3\alpha_4\beta_4\alpha_5$. The separate Δ magnitudes are combined thus:

Mean of $\alpha_1\alpha_2\alpha_3$	=0.527 mag.
Mean of $\beta_1\beta_2$	.568
Diff. in Δ mag.	.041
Sector	.443
True diff. $(\beta-\alpha)$	.402

When the light fluctuations are very rapid, as is the case with *β Cephei*, it is desirable to have the separate points as close together as possible in order to show the true shape of the light-curve. For this reason I adopted the plan of employing intermediate points, which are obtained by combining the last measures in one observation with the first measures in the succeeding observation. Thus in the case cited above, the intermediate point is obtained by combining $\alpha_2\beta_2\alpha_3\beta_3\alpha_4$. In Table VIII these intermediate points are given in the same way as the others. The result of the above process is to diminish the weights of all the points, because they are not strictly independent.

OBSERVATIONS OF THE PLEIADES

Observations have been made on the *Pleiades* for the double purpose of testing the accuracy and range of the photometer, and of checking the conclusion derived in the laboratory that the illumination-current relation for the photo-electric cell is linear proportionality for stellar intensities. The stars observed were those designated by Bessel as *η, b, c, d, e, f, g, h, l,* 28, 32, 34 and 38; they range in brightness from 2.87 mag. to 6.74 mag., and they belong to some one of the spectral classes B5, B8 or B9. These stars are thus so nearly of the same class that the color-indices can (for the present purpose) be assumed to be equal,[20] and it does not greatly matter whose magnitude determinations are employed for purposes of comparison with the photo-electric magnitudes. I used the photographic magnitudes as derived by Schwarzschild.[21] If Schwarzschild's magnitudes and the photo-electric Δ magnitudes are both on a scale consistent with Pogson's rule, then when the former are plotted against the latter, the resulting curve should be a straight line with a slope of 45 degrees. The deviations from this line will furnish an indication of the accuracy of the observations and will serve to show for how great a range of magnitudes the cell exhibits illumination-current proportionality.

It was found that for each of the 13 series of observations made on 6 different nights a 45 degree line represents the points very well. This work is considered to be only preliminary and the data are too meager to justify drawing positive conclusions regarding the accuracy of the measures; but it appears thus far that two stars as faint as 6.7 magnitude can be compared with accuracy only slightly less than that for the brighter stars, in spite of the fact that the rates for the faint stars are very slow and the various corrections (see p. 112) proportionately greater. It should be stated, however, that the fainter stars of the sequence were not measured at all on those nights when the dark-current, background or leakage were appreciable. For the present it is not considered feasible to attempt measures of stars fainter than those in this sequence. But subsequent work on the characteristic curves (cf. p. 106) may show that anode potentials greater than 310 volts can be safely employed for the fainter stars, in which case the range of the pohtometer may be considerably increased.

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[18] *Veröffent. Berlin-Babelsberg,* **2**, part 3, page 36.

[19] *Ap. Jour.* **49**, 303, 1919.

[20] In *Lick Obs. Bull.* **10**, 111, 1921, are given Hertzsprung's values for the color-indices of the *Pleiades*. For the stars which I observed most frequently (*η* to *h* inclusive) the indices range from −0.18 to −0.22 mag. For the fainter stars the indices are smaller.

[21] *Göttingen Aktinometrie,* B, p. 14.

CALIBRATION OF THE SECTORED DISKS

To date seven sectored disks have been made. They diminish the light by about ¼, ½, 1, 1½, 2, 2½ and 3 magnitudes respectively. The calibrating of the sectors could be done in daytime with an artificial light source, but it was found convenient to do the work at night. Measures were made in the same way as when two stars are compared,—4 settings with the sectored disk stopped, 4 with disk revolving, 4 with disk stopped, and so on. These measures are reduced in the same way as star measures. Each observation consisted of 15 or 20 separate settings. The Δ magnitude differences "sector *minus* clear aperture" give the value of the sector. The results of the calibration are given in Table VI. This table gives accurate values for the first, second, third and fifth sector, and the approximate value for the seventh. The fourth and sixth sectors have not been calibrated as yet. The probable errors in the third column of the table illustrate the point that large differences of magnitude cannot be observed so accurately as small differences. In the case of the quarter-magnitude sector, the probable error of a single observation consisting of 20 settings was ±.008 mag.

TABLE VI

VALUES OF THE SECTORED DISKS

Disk No.	ΔMag.	Prob. error	Number of determinations
1	0.232	±.002	24
2	0.443	±.004	14
3	0.90	±.01	20
5	1.93	±.02	11
7	2.76		4

It is expected that in the course of the photometric work here special sectors will be made in every case where the observer wishes to attain high accuracy by bringing the stars under observation to very nearly the same brightness.

It might be of theoretical interest to measure accurately the apertures of the sectors and to see how close is the agreement between the percentages thus determined and the observed values. It is known that the transmission of sectors as measured photographically is not strictly proportional to the sector openings. Coblentz[22] and Fowle[23] have found that when a sectored disk is used with a thermopile, the energy transmitted is greater than the theoretical value. But in a letter Dr. Coblentz states that he observed this phenomenon only when using a radiometer and that no such effect was found by him in photo-electric photometry. Moreover, Kunz[24] and Ives[25] have found that Talbot's law holds very exactly for photo-electric cells.

COLOR-INDEX CURVE AND COLOR-EQUATION

In February and March, 1921, and again in September, observations were made for determining the color-index curve for the photometric system. For this purpose groups of stars were chosen so that the different members were at about the same altitude and of various spectral classes. Each group contained at least one star of class A0. For instance, one group consisted of δ, σ, η, ϵ, ρ and 16 *Hydrae.* Of these, two are of class A0, two of class K0, and one each of classes B3 and F8. The visual magnitudes range from 3.30 to 4.54. In choosing the groups an effort was made to have A0 stars with visual magnitudes as near as possible to those of the other stars. The best arrangement is to have the A0 stars at the ends of the series.

The observations were made in the usual manner, from 4 to 6 settings on each star. Sectors were used in a few cases, where certain stars were more than a magnitude brighter than the others in the group. But no attempt was made consistently to equalize the stars so as to conform with the half-magnitude rule. Thus the errors may be large, but on the average they will balance. Generally the range of brightness in a given group was less than two magnitudes, and in only one case was it as great as 3.1 mag.

The reductions to Δ magnitude are made in the usual way. Then for each group of stars the photo-electric Δ magnitudes are plotted against the Harvard visual magnitudes. If, now, one connects all the points for the stars of a certain spectral class, the curves should approximate straight lines with a slope of 45 degrees. It was found that in general this condition was fulfilled very well. The deviations from the 45 degree line will be due not only to errors in the observations but also to the inaccuracy of the assumption that all stars of one spectral class have the same color-index.[26] Added to these errors are those inherent in the Harvard magnitudes and spectral classifications. For about half of the stars observed, the Henry Draper classification was not available, and it was necessary to use the values given in the *Revised Harvard Photometry*. The abscissae of such points may in some cases be in error by several tenths of a spectral class.

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[22] *Bull. of Bur. of Stand.* **4,** 455, 1907; also, No. 319, p. 535.

[23] *Smithsonian Miscell. Coll.* **68,** No. 8, p. 14, 1917.

[24] *Ap. Jour.* **45,** 69, 1917.

[25] *Ap. Jour.* **43,** 24, 1916.

Having drawn a 45-degree line to represent as nearly as possible the A0 stars in a group, I next measured the vertical distance from this line to each of the other stars, thus obtaining their color-indices. In all, 15 groups were observed, yielding the color-indices of 60 stars. In Figure 12 are shown the individual points.

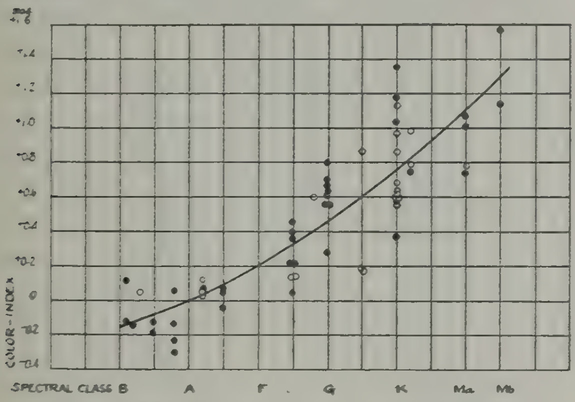

Fig. 12. Color-index curve for the Photometric system.

It is not possible to draw a satisfactory curve through them, but the curved line in the figure is perhaps a fair compromise. Table VII is made by reading from the smooth curve the mean color-index for each spectral class. *The provisional value for the color-equation*[27] *of the photometer when used with the* 12*-inch refractor and with the cell Q, is* +0.76 *mag.*

TABLE VII

COLOR-INDICES (PROVISIONAL VALUES)

Spectral Class	Color Index mag.
B0	−0.14
B5	−0.08
A0	0.00
A5	+0.10
F0	+0.22
F5	+0.32
G0	+0.45
G5	+0.60
K0	+0.76
K5	+0.92
Ma	+1.10
Mb	+1.28

The color-index curve (Fig. 12) depends principally upon the color-sensitiveness curve of the cell; if there are changes in the cell which alter its color-sensitiveness curve we cannot legitimately combine color-index measures taken on widely separate dates; indeed the terms color-index and color-equations will be meaningless. Ives [28] has published an account of observing a progressive change in the λ–sensitiveness curve of a potassium-helium cell. But I have found no published account of similar behaviour in the case of argon-filled cells. Shinomya,[29] who studied intensively the λ–sensitiveness curves for the cells made by Professor Kunz, makes no mention of such a phenomenon. In Figure 12 the points were observed at two dates separated by about seven months; the points designated by circles are the early observations. There is no good evidence here of any marked change in the color-index curve between the two epochs.

A STUDY OF β *Cephei*

The study of a variable star was undertaken as a further test of the photometer. For this purpose β *Cephei* was chosen, primarily because it has been observed[30] with the photo-electric photometer at Berlin-Babelsberg. Thus the results obtained serve the purpose of comparing the performance of the present photometer with that of another instrument of the same class.

The Observations. The star was observed on 16 nights from 1921, June 30, to September 22, inclusive. α *Cephei* (visual magnitude 2.60, Class A5) was used as comparison star, its brightness reduced with the 0.443 magnitude sector. Guthnick and Prager employed this same comparison-star, and they have shown that its light is constant, at least for long intervals.

TABLE VIII

OBSERVATIONS OF β CEPHEI

G.M.T.	Helioc. phase	$\beta-\alpha$ (mag.)	O−C (mag.)
1921 June 30^{d}.803	0^{d}.116	0.373	−.006
.813	.126	.329	−.035
July 7.840	.106	.379	−.010
.849	.115	.374	−.006
.858	.124	.362	−.007
July 10.807	.025	.331	−.026
.816	.034	.311	−.050
.824	.041	.341	−.024
.832	.049	.348	−.022
.841	.059	.395	+.017
.850	.068	.389	+.005

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[26] This latter source of error is not so serious as might be supposed, because the late-type stars observed were all of visual magnitude 5.0 or brighter. I am told by specialists in the subject that all such stars are "giants;" thus the present problem is not complicated by the matter of the variation of the color-indices of the late-type stars as a function of their absolute magnitudes.

[27] That is, the difference in photo-electric magnitude between A0 and K0 stars of the same visual magnitude.

[28] *Ap. Jour.* **46**, 241, 1917.

[29] *Ap. Jour.* **49**, 303, 1919.

[30] *Veröffent. Berlin-Babelsberg*, **1**, part 1, page 23, 1914. *Veröffent. Berlin-Babelsberg*, **2**, part 3, page 78, 1918.

TABLE VIII—*(Continued)*

G.M.T	Helioc. phase	$\beta-\alpha$ (mag.)	O−C (mag.)
1921 July 11^{d}847	0^{d}112	0.358	−.026
.854	.120	.361	−.012
.862	.128	.357	−.005
.869	.135	.337	−.019
.876	.142	.339	−.014
.883	.149	.336	−.021
July 13.828	.188	.328	−.015
.838	.008	.323	−.020
.849	.019	.351	0
.858	.028	.392	+.035
.867	.037	.379	+.017
July 14.796	.013	.365	+.019
.803	.020	.323	−.028
.810	.027	.326	−.031
.817	.035	.362	+.001
.824	.041	.387	+.022
.831	.049	.387	+.018
.840	.057	.374	−.002
.847	.065	.387	+.006
.854	.072	.391	+.005
.862	.079	.378	−.011
July 15.837	.102	.397	+.006
.844	.110	.394	+.008
.853	.118	.369	−.007
.861	.126	.357	−.007
July 18.779	.188	.346	+.003
.788	.006	.328	−.013
.825	.043	.325	−.041
.833	.042	.348	−.023
.840	.059	.345	−.033
.849	.067	.369	−.014
Aug. 15.729	.138	.361	+.007
.737	.146	.346	−.009
.744	.154	.362	+.002
.751	.160	.363	−.001
.760	.168	.383	+.021
.769	.177	.357	+.004
.778	.187	.365	+.022
.789	.008	.373	+.030
.909	.128	.385	+.023
.921	.139	.356	+.003
.929	.148	.320	−.036
.938	.156	.343	−.019
.946	.164	.368	+.004
.954	.172	.377	+.019
.962	.180	.368	+.020
.972	.190	.381	+.040
Aug. 17.706	.020	.358	+.007
.712	.026	.354	−.003
.721	.035	.351	−.010
.728	.042	.332	−.033
.735	.049	.359	−.010
.742	.056	.383	+.008
.749	.062	.402	+.021
.798	.070	.402	+.017
.804	.076	.384	−.005
.811	.083	.390	−.001
.819	.091	.400	+.008
.826	.099	.398	+.006
.882	.005	.346	+.005
.889	.012	.350	+.004

G.M.T.	Helioc. phase	$\beta-\alpha$ (mag.)	O−C (mag.)
1921 Aug. 18^{d}721	0^{d}082	0.373	−.018
.728	.089	.368	−.024
.733	.095	.367	−.025
.742	.103	.372	−.019
.750	.112	.384	−.001
.757	.118	.377	+.001
.764	.125	.368	+.004
.772	.134	.360	+.003
.779	.141	.352	−.001
.786	.148	.371	+.014
Aug. 29.674	.178	.338	−.014
.683	.188	.323	−.020
.690	.004	.335	−.006
.697	.011	.337	−.007
.704	.018	.365	+.015
.713	.027	.376	+.019
.722	.036	.375	+.013
.729	.043	.371	+.006
.736	.050	.398	+.028
.743	.057	.401	+.025
.750	.064	.403	+.022
.758	.072	.383	−.003
.840	.154	.384	+.023
.849	.163	.371	+.007
.857	.171	.362	+.003
.865	.178	.331	−.021
.872	.185	.319	−.024
.881	.005	.347	+.006
.890	.014	.369	+.023
.897	.021	.372	+.020
.906	.030	.373	+.014
Aug. 30.664	.026	.350	−.007
.674	.035	.355	−.006
.682	.044	.366	.000
.687	.048	.379	+.010
.693	.055	.355	−.018
.699	.060	.354	−.025
.706	.067	.358	−.025
.711	.073	.370	+.025
.717	.078	.382	−.007
.721	.082	.382	+.009
.728	.089	.365	−.027
.735	.097	.363	−.019
.742	.103	.379	−.012
.749	.110	.363	−.023
.756	.117	.354	−.022
.857	.028	.360	+.003
.865	.036	.350	−.012
.874	.045	.374	+.008
.881	.052	.384	+.012
.888	.059	.351	−.027
.893	.064	.374	−.007
.899	.070	.393	+.008
.906	.077	.379	−.009
.911	.082	.372	−.019
.918	.089	.398	+.006
Aug. 31.678	.088	.390	−.002
.685	.094	.385	−.007
.691	.100	.410	+.018
.697	.106	.408	+.019
.704	.113	.407	+.024
.710	.119	.393	+.018
.717	.126	.378	+.014

TABLE VIII—(*Continued*)

G.M.T	Helioc. phase	$\beta-\alpha$ (mag.)	O−C (mag.)
1921 Aug. 31$^{\mathrm{d}}$724	0$^{\mathrm{d}}$133	0.342	−.015
.731	.140	.342	−.011
.738	.147	.333	−.022
.744	.154	.351	−.010
.751	.160	.355	−.008
.757	.166	.363	.000
.861	.080	.422	+.032
.868	.087	.407	+.015
.875	.094	.400	+.008
.881	.099	.391	−.001
888	.107	.379	−.010
.896	.115	.390	+.010
.903	.122	.372	+.002
.910	.128	.368	+.006
.915	.134	.370	+.014
Sept. 21 .658	.115	.413	+.033
.664	.121	.403	+.031
.671	.128	.380	+.018
.678	.135	.386	+.030
683	.140	.371	+.018
.690	.147	.374	+.018
.696	.154	.374	+.013
.794	.060	.408	+.029
.804	.070	.394	+.008
.814	.080	.379	−.011
.822	.089	.392	.000
.831	.097	.407	+.015
.840	.106	.397	+.008
Sept. 22 .635	.139	.366	+.013
.640	.145	.368	+.013
.648	.153	.382	+.022
.655	.160	.371	+.008
.661	.166	.359	−.004
.668	.173	.354	−.005
.676	.181	.340	−.009
.683	.188	.363	+.020
.689	.003	.336	−.005
.696	.010	.321	−.022

In Table VIII are given the individual observations. About half these points are based upon 20 settings each; the rest, upon 15 settings each. The phases were at first computed using the elements:[31] Helioc. Max. = 1913, August 5.350 (J. D. 2419985.350) G.M.T.

$$+E\times 0^{\mathrm{d}}190479$$

The resulting mean curve showed the maximum at phase about +$^{\mathrm{d}}$006 or +$^{\mathrm{d}}$010. This was taken to be a confirmation of Crump's[32] correction +$^{\mathrm{d}}$0000005 to the period. Confirmation has been given also by Henroteau and Henderson.[33] Adopting the elements: Helioc. Max. = 1913 August 5.350 (J.D. 2419985.350) G.M.T.

$$+E\times 0^{\mathrm{d}}1904795$$

I recomputed the phases, thus shifting the curve to the left by 0$^{\mathrm{d}}$008 and bringing the maximum to zero phase.

The phases in column 2 of Table VIII are those computed by the corrected elements. The 3rd column gives the magnitude difference, β *minus* α; the 4th column, the residual of each point from the computed curve (Fig. 14). From these residuals it appears that the probable error of a single observation is ±.012 mag.

An examination of the individual observations at separate dates inclines the writer to think that the behavior of this star is not consistent but varies from epoch to epoch, although on any two consecutive epochs the light curves are about the same. Support for this view is given by an examination of the two sets of observations obtained on August 15 (epochs 15394, 15395, 15396), on August 29 (epochs 15467, 15498, 15468), on August 30 (epochs 15473 and 15474), and on August 31 (epochs 15478 and 15479). These observations are shown in Figure 13. Significant, in this connection, is the fact that Crump[34] and Henroteau[35] have reported that the *velocity* curve of this star is not constant. The photometric data are too few to justify drawing positive conclusions from them. The point should be tested by an extensive series of observations taken so as to include consecutive epochs on many different nights. It would be interesting to compare such light curves with velocity curves obtained simul-

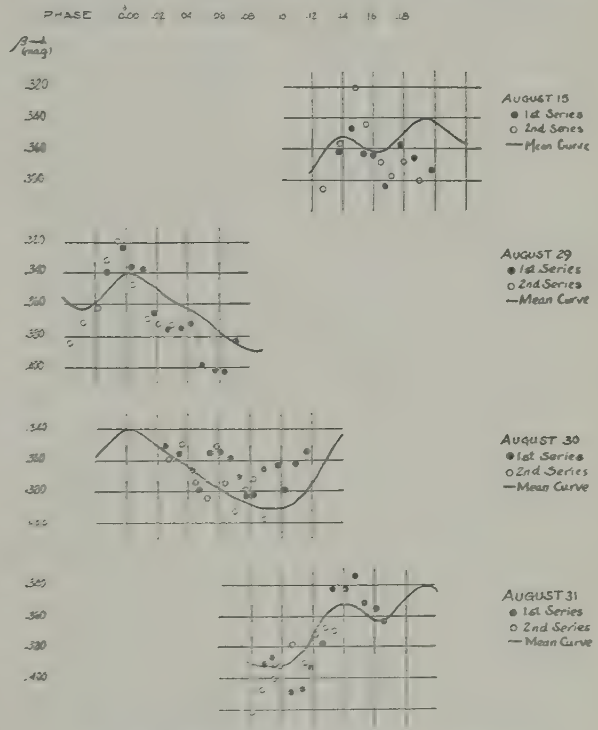

Fig. 13. Individual observations of β *Cephei* at successive epochs.

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[31] *Veröffent. Berlin-Babelsberg*, **1**, part 1, page 34.

[32] *Publ. Detroit Obs.* **2**, 151, 1916.

[33] *Pubs. Dominion Obs.* **5**, 83, 1921.

[34] *Publ. Detroit Obs.* **2**, 153-156, 1916.

[35] *Publ. Dominion Obs.* **5**, 77, 1921.

taneously. Do such light-variations as those of August 15 (cf. following paragraph) occur synchronously with unusual velocity variations such as were observed by Crump on October 1, 1912?

Normal Places and Mean Curves. The individual points of Table VIII have been combined into 43 normal places whose coördinates are given in Table IX.

TABLE IX

Observations of β Cephei, *Normal Places*
(including all observations)

Number of the normal place	Phase	$\beta-\alpha$ (mag.)	O−C (mag.)
1	$0^{\mathrm{d}}003$	0.349	+.008
2	.007	.343	+.001
3	.012	.348	+.003
4	.017	.361	+.012
5	.023	.344	−.010
6	.028	.354	−.003
7	.032	.357	−.003
8	.036	.361	.000
9	.041	.360	−.004
10	.044	.359	−.007
11	.049	.368	−.001
12	.052	.371	.000
13	.057	.376	.000
14	.060	.377	−.002
15	.064	.391	+.010
16	.068	.379	−.005
17	.071	.390	+.004
18	.076	.389	+.001
19	.080	.388	−.002
20	.084	.388	−.003
21	.089	.387	−.005
22	.092	.387	−.005
23	.097	.386	−.006
24	.101	.393	+.002
25	.105	.391	+.001
26	.110	.380	−.006
27	.114	.382	+.001
28	.117	.377	.000
29	.120	.381	+.008
30	.125	.366	.000
31	.128	.363	+.002
32	.132	.360	+.002
33	.136	.357	+.002
34	.140	.353	.000
35	.145	.355	+.001
36	.148	.350	−.006
37	.154	.367	+.006
38	.158	.363	.000
39	.163	.366	+.002
40	.169	.370	+.010
41	.176	.345	−.009
42	.184	.347	+.002
43	.188	.341	−.001

Each normal place includes 4 points, except the 29th, which contains 5 points. The normal places are shown in Figure 14; the smooth curve is a computed harmonic curve for which the equation is:

$$\begin{aligned} y=0.3665^{\mathrm{mag}} & -0.0202\cos\theta+0.0032\cos 2\theta \\ & -0.0048\cos 3\theta-0.0031\cos 4\theta \\ & +0.0034\sin\theta-0.0048\sin 2\theta \\ & -0.0033\sin 3\theta+0.0011\sin 4\theta \end{aligned}$$

Column 4 of Table IX gives the residuals from the computed curve. From these residuals it is found that the probable error of a normal place is ±.004 mag.

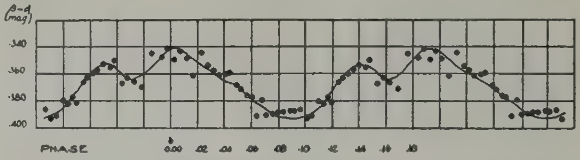

Fig. 14. β *Cephei*, normal places and computed light curve.

A conspicuous feature of the mean curve in Figure 14 is the secondary maximum on the ascending branch at about $0^{\mathrm{d}}14$ phase. This secondary maximum is accentuated by the observations of August 15 which, though agreeing among themselves, differ markedly

TABLE X

Observations of β Cephei, *Normal Places*
(excluding observations of 1921, August 15)

Number of the normal place	Phase	$\beta-\alpha$ (mag.)	O−C (mag.)
1	$0^{\mathrm{d}}003$	0.341	+.007
2	.007	.330	−.006
3	.012	.355	+.013
4	.019	.348	−.002
5	.024	.352	−.001
6	.028	.363	+.007
7	.034	.350	−.009
8	.036	.364	+.004
9	.042	.358	−.006
10	.045	.361	−.005
11	.050	.373	+.003
12	.053	.368	−.005
13	.058	.379	.000
14	.061	.379	−.003
15	.065	.383	−.001
16	.069	.385	−.001
17	.072	.395	+.008
18	.078	.381	−.007
19	.082	.389	.000
20	.086	.390	+.001
21	.090	.381	−.008
22	.093	.393	+.004
23	.098	.392	+.003
24	.102	.389	.000
25	.106	.391	+.003
26	.111	.374	−.011
27	.114	.396	+.014
28	.118	.368	−.008
29	.120	.382	+.009
30	.125	.366	+.001
31	.128	.359	−.001
32	.134	.352	−.004
33	.139	.358	+.003
34	.144	.356	−.002
35	.148	.360	−.002
36	.154	.369	+.003
37	.158	.370	+.004
38	.164	.364	+.002
39	.174	.350	.000
40	.181	.332	−.006
41	.187	.338	+.005

from the other series of observations. I have recomputed the normal places, excluding the observations of August 15. These new normal places are given in Table X and Figure 15. Each normal place consists of 4 points, except numbers 35 to 41, inclusive, which contain 3 points each. For the harmonic curve in Figure 15 the equation is:

$$\begin{aligned} y=0.3653^{\text{mag}}&-0.0225\cos\ \theta+0.0005\cos 2\theta \\ &-0.0049\cos 3\theta-0.0048\cos 4\theta \\ &+0.0013\sin\ \theta-0.0052\sin 2\theta \\ &-0.0033\sin 3\theta+0.0017\sin 4\theta \end{aligned}$$

If this star really has an inconstant light curve, then probably Figure 15 represents the *average* course of the variation better than does Figure 14.

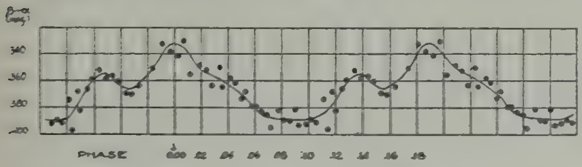

Fig. 15. β *Cephei*, normal places and computed light curve (excluding observations of Aug. 15, 1921).

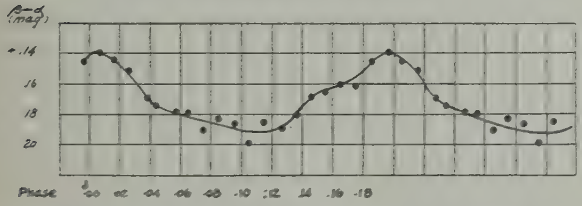

Fig. 16. Mean light curve or β *Cephei*, by Guthnick and Prager, 1913–1914. Each normal place is the mean of from 5 to 13 observations.

Comparison with Berlin-Babelsberg Light Curves. It is of interest to note that in Guthnick and Prager's[36] mean curve for 1913–1914, which is shown in Figure 16, there is an indication of a secondary wave in the ascending branch. For purposes of further comparison with Guthnick and Prager, an examination was made of their observations[37] taken January 14 to February 4, 1917. There are a few measures with blue filter and some in which 11 *Cephei* was used as comparison star; but the number of these points is so small that they cannot be used for the present purpose. There are, however, 45 measures with yellow-filter where the comparison star was α *Cephei*. These have been combined by the writer into normal places containing 2 or 3 observations each (see Table XI). The points thus formed are plotted in Figure 17. There is plain indication here of a secondary maximum such as appears in the Lick Observatory curve. In Table XII is given a comparison of the light curves as observed here and at Berlin-Babelsberg.

TABLE XI

OBSERVATIONS OF β CEPHEI AT BERLIN-BABELSBERG (JANUARY 14–FEBRUARY 4, 1917), COMBINED INTO *Normal Places*

Number of the normal place	Phase	β−α (mag.)
1	0ᵈ001	0.472
2	.006	.491
2	.012	.479
4	.018	.492
5	.029	.496
6	.037	.500
7	.049	.502
8	.054	.496
9	.070	.520
10	.089	.531
11	.108	.515
12	.127	.493
13	.134	.486
14	.145	.473
15	.154	.474
16	.164	.480
17	.175	.473
18	.183	.457
19	.188	.462

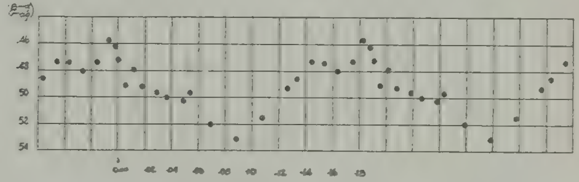

Fig. 17. Guthnick and Prager's observations of β *Cephei*, Jan. 14–Feb. 4, 1917. Each normal place is the mean of 2 or 3 observations.

TABLE XII

COMPARISON OF MEAN LIGHT-CURVES OF β CEPHEI

Curve	Range mag.	Length of descending branch days	Length of ascending branch days
Lick, 1921 (curve including all points)	0.051	0.09	0.10
Lick, 1921 (curve excluding observations of August 15)	0.056	0.10	0.09
Berlin-Babelsberg, 1913–1914	0.053	0.11	0.08
Berlin-Babelsberg, January and February, 1917	0.074	0.09	0.10

Comparison with Spectroscopic Observations. The velocity variations of β *Cephei* have been studied by Frost,[38] Crump,[39] and Henroteau.[40] Guthnick and Prager compared[41] their 1914 light curve with Frost's spectroscopic observations taken near the same time and concluded that the maximum light came 0ᵈ034 before the descending node. Crump gives a figure which compares his velocity curve of 1912 with Guthnick and Prager's 1914 light curve; this comparison shows the maximum velocity of approach as occurring about 0ᵈ027 after the light maximum, and the minimum velocity of approach as occurring about 0^{d}031 after the light minimum.

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[36] *Veröffent. Berlin-Babelsberg*, **1**, part 1, page 34.

[37] *Veröffent. Berlin-Babelsberg*, **2**, part 3, page 151, 1918.

[38] *Ap. Jour.* **24**, 259, 1906.

[39] *Publ. Detroit Obs.* **2**, 144, 1916.

[40] *Publ. Dominion Obs.* **5**, 77, 1921.

[41] *Veröffent. Berlin-Babelsberg*, **1**, part **1**, page 37, 1914.

For each of the 6 cycles which were observed in 1920 by Henroteau and Henderson I have computed the times of maximum light, and compared these with the observed times of maximum velocity of approach. Also, I computed the times of minimum light (by adding to the time of maximum the value 0^{d}092 for the value M—m) and compared these with the observed times of minimum velocity of approach. On the average the maximum velocity of approach occurred 0^{d}041 later than the computed times of maximum light; the minimum velocity of approach, 0^{d}042 later than the computed times of minimum light.

Recently a series of plates of *β Cephei*, completely covering one cycle, was taken here with the 3-prism Mills spectrograph. Since these plates were obtained only a month and a half after the last photometric observations, they ought to furnish a reliable comparison between the spectroscopic orbit and the light curve. The plates were kindly measured by Miss Hobe, Assistant in the Observatory, who found the velocities to be:

Date	Velocity
J.D. 2423000.573	+ 9.9 km.
.586	+12.2
.596	+10.8
.610	+ 3.6
.631	− 6.2
.648	−13.8
.666	−17.2
.684	−13.6
.702	−12.4
.720	− 4.9
.738	+ 3.2
.753	+10.6
.778	+13.0
.795	+ 9.8
.811	+ 1.8
.827	− 1.1

The maximum velocity of approach (as read from a smooth curve) occurred about 0^{d}030 after the computed time of light maximum; the minimum velocity of approach occurred about 0^{d}040 after the computed time of

TABLE XIII

Comparisons between Photometric and Spectroscopic Data for β Cephei

(on the assumption of a circular orbit)

Berlin-Babelsberg Light-Curve (1914) and Yerkes Spectroscopic Observations (1914).	Berlin-Babelsberg Light-Curve (1914) and Detroit Spectroscopic Observations (1912).	Lick Light-Curve (1921) and Ottawa Spectroscopic Observations (1920)	**Lick Light Curve (1921) and Lick Spectroscopic Observations (1921).**
Maximum light 0^{d}034 (65°) before descending node.	Maximum light 0^{d}027 (51°) before descending node.	Maximum light 0^{d}041 (78°) before descending node	**Maximum light 0^{d}030 (57°) before descending node.**
Minimum light 0^{d}025 (47°) before ascending node.	Minimum light 0^{d}031 (59°) before ascending node.	Minimum light 0^{d}042 (80°) before ascending node.	**Minimum light 0^{d}040 (76°) before ascending node.**
		Secondary light maximum 0^{d}005 (9°) after ascending node.	
		Secondary light minimum 0^{d}027 (51°) after ascending node.	

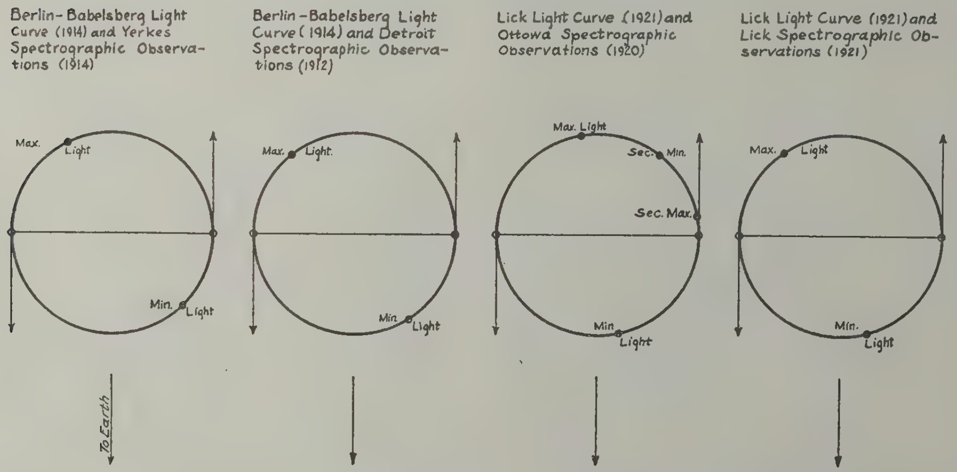
Berlin-Babelsberg Light Curve (1914) and Yerkes Spectrographic Observations (1914)
Berlin-Babelsberg Light Curve (1914) and Detroit Spectrographic Observations (1912)
Lick Light Curve (1921) and Ottowa Spectrographic Observations (1920)
Lick Light Curve (1921) and Lick Spectrographic Observations (1921)
Max. Light
Min. Light
Max. Light.
Min. Light
Max. Light
Sec. Min.
Sec. Max.
Min. Light
Max. Light
Min. Light
To Earth

Fig. 18. Comparison of Photometric and Spectroscopic results, on the assumption of a circular orbit.

light minimum. The above observations serve also as a confirmation of the period, checking exactly the correction of $+^{d}_{.}0000005$.

In Table XIII are gathered the four different comparisons between velocity curves and light curves; the data are represented graphically in Figure 18, under the assumption of a circular orbit.

Conclusions. It has been customary to class *β Cephei* as a variable of *δ Cephei* type, in spite of its early spectrum (B1), the small eccentricity of its orbit, and other characteristics which have been mentioned in the preceding discussion. To the writer it seems advisable to consider this star as in a class by itself, and to look hopefully among early type stars for other examples.

When the facts set forth in preceding paragraphs are reviewed a few features stand out prominently:

1st, the similarity in shape of light curves observed on successive epochs, the disparity between individual curves observed at separate epochs, and the agreement in shape of *mean* curves derived at intervals of several years;

2nd, the variation in velocity curves, reported by Crump and by Henroteau;

3rd, the four comparisons between light and velocity curves, showing that the light maximum occurs about one-fifth of the period earlier than the greatest velocity of approach.

These points are difficult to explain on the hypothesis of simple orbital motion, or on any other theory which has been proposed. To the writer it seems unlikely that the peculiar behavior of *β Cephei* can be explained without the introduction of factors as yet unconsidered in theories regarding fluctuations in the light and velocity of stars.

SUMMARY

The photo-electric photometer of the Lick Observatory differs from other photometers of the same class in numerous details, most conspicuous of which is the mechanism for reducing the incident light in a known ratio. Other workers in this field have used objective diaphragms or neutral-tinted shade glasses for that purpose; in the present instrument sectored disks driven by a small motor intermittently occult the incident beam. Additional respects in which this photometer differs from others are the manner of rotating the instrument, the optical system of the electrometer and the mechanism for operating the grounding key.

Two potassium-argon photo-electric cells were studied to determine their fitness for use in the photometer. The characteristic curves showed that for a given voltage the quartz cell is about twice as sensitive as the glass cell, and the former has other qualities which make it preferable. A series of characteristic curves of the quartz cell, taken with different illuminations, showed that for a 3rd magnitude star a potential of 310 volts can safely be used; for objects brighter than 1.0 magnitude 260 volts or less must be employed. Investigation of the illumination-current relation for the quartz cell proved that this relation is linear within the limits of illumination which are encountered in stellar photometry. For greater intensities there are deviations from a straight line.

In the autumn of 1920 the photometer was mounted on the 12-inch refractor, and since that time it has been employed in observations of stars. A sequence in the *Pleiades* was measured as a check on the laboratory calibration and found to verify the conclusion stated above. Series of stars of different spectral classes were observed in order to derive the color-equation and the color-index curve for this photometric system. The provisional value of the color-equation is +0.76 mag.

Seven sectored disks have been made to date; they cut down the incident light by about ¼, ½, 1, 1½, 2, 2½, and 3 magnitudes, respectively. The exact values for the ratios of the 1st, 2nd, 3rd and 5th were derived by observations on stars.

A mean light curve of the star *β Cephei* was derived in the summer of 1921. The separate series of observations indicate that the light curve is not constant, although it is apparently about the same for two consecutive epochs. The mean curve differs slightly in form from that of Guthnick and Prager and a small correction to the period is indicated. The corrected period is in agreement with the spectroscopic period derived by Crump, and it is checked by recent spectrographic observations made here. Four comparisons of photometric with spectrographic data show that the light maximum occurs (in the mean) about 0.033 days before the maximum velocity of approach. On the assumption of a circular orbit, the difference in the anomaly is 62 degrees, or 0.17 of the period of variation.

When two stars *a* and *b* are being compared a single observation consists generally of 20 settings in the order *aaaa bbbb aaaa bbbb aaaa*. In order to determine the probable error of such an observation, measures of one star were alternated with measures of the same object when diminished with the ¼-magnitude sectored disk. The probable error of an observation was found to be ±.008 mag. In the case of *β Cephei* the individual observations were compared with a harmonic curve of 9 constants; the residuals thus formed give for the probable error ±.012 mag. The accuracy of the photometer is greater than would be indicated by the above figure if, as seems likely, the curve of *β Cephei* is not really constant.

EDITH E. CUMMINGS.

LICK OBSERVATORY,
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ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 350

ELEMENTS AND EPHEMERIS OF MINOR PLANET 1923 PE

The following observations were made the basis of the determination of a preliminary orbit of Minor Planet 1923 PE. The orbit represents a direct solution by Leuschner's method with a single differential correction to reduce residuals.

1923 Gr. M. T.	Planet's α (1923.0)	Planet's δ (1923.0)	Observed at
Nov. 5.3440	$1^h\ 17^m\ 59^s.9$	$+19^\circ\ 47'\ 23''$	Königstuhl
Nov. 10.6607	1 21 30.4	+16 54 14	Washington
Nov. 13.5843	1 23 56.5	+15 20 26	Washington

Elements

$T = 1923$ Nov. 29.9869 Gr. M. T.

$$\left.\begin{array}{l}\omega = 184^\circ\ \ 4'.5\\ \Omega = 232\ \ \ 9.6\\ i = 11\ \ \ 19.8\end{array}\right\}1923.0$$

$e = 0.3024$

$a = 1.8729$

$\mu = 1384''.3$

Period $= 2.56$ years

O−C	I	III
$\cos\delta\,\Delta\alpha$	$-\ 2''$	$-1''$
$\Delta\delta$	-22	-1

Because of the motion of the object, these residuals were considered satisfactory.

Constants for the Equator 1923.0

$$x = r\,[9.99470]\sin(145^\circ\ 41'.2 + v)$$
$$y = r\,[9.98234]\sin(\ 53\ \ \ 3.8 + v)$$
$$z = r\,[9.50480]\sin(\ 83\ \ 26.5 + v)$$

The elements and an ephemeris based upon them were published in *Harvard College Observatory Bulletin*, Number 794.

A second orbit was based upon the following observations:

1923 Gr. M. T.	Planet's α (1923.0)	Planet's δ (1923.0)	Observed at
Nov. 5.3440	$1^h\ 17^m\ 59^s.9$	$+19^\circ\ 47'\ 23''$	Königstuhl
Nov. 21.8240	1 32 22.98	+11 12 10.5	Williams Bay
Dec. 10.6733	1 59 13.77	+ 4 18 34.3	Williams Bay

Elements

$T = 1923$ Nov. 29.6504

$$\left.\begin{array}{l}\omega = 183^\circ\ 32'\ 14''\\ \Omega = 229\ \ 35\ \ 51\\ i = 15\ \ 42\ \ 42\end{array}\right\}1923.0$$

$e = 0.451017$

$a = 2.61196$

$\mu = 840''.538$

Period $= 4.2213$ years

$$\left.\begin{array}{l}\omega = 183^\circ\ 32'\ 13''\\ \Omega = 229\ \ 36\ \ 43\\ i = 15\ \ 42\ \ 42\end{array}\right\}1924.0$$

Constants for the Equator 1923.0

$$x = r\,[9.990564]\sin(142^\circ\ \ 3'\ 17'' + v)$$
$$y = r\,[9.989021]\sin(\ 49\ \ 18\ \ 14\ + v)$$
$$z = r\,[9.481491]\sin(\ 93\ \ 33\ \ 51\ + v)$$

Constants for the Equator 1924.0

$$x = r\,[9.990559]\sin(142^\circ\ \ 4'\ \ 8'' + v)$$
$$y = r\,[9.989020]\sin(\ 49\ \ 19\ \ 3\ + v)$$
$$z = r\,[9.481537]\sin(\ 93\ \ 35\ \ 2\ + v)$$

O−C	I	III
$\cos\delta\,\Delta\alpha$	$-1''$	$+2''$
$\Delta\delta$	0	$+1$

A comparison of the second orbit with other available observations reveals a discrepancy of about 1′ in at least one observation. It appears, however, that the second orbit is consistent with additional observations made at the Yerkes Observatory on November 24 and 28.

The orbit of this object resembles that of (719) Albert (1911 MT) for which Dr. E. S. Haynes computed the elements (*Lick Observatory Bulletins* 216, 220, 222), except for a large discrepancy in the longitude of perihelion. The question of the identity of the two objects must be deferred until a somewhat definitive orbit of 1923 PE shall have been determined.

This object was announced originally as of cometary appearance (*Harvard College Observatory Bulletin*, Number 793). Subsequent visual observation by Van Biesbroeck of the Yerkes Observatory with the 40-inch telescope indicates that the object should be classed as a minor planet.

EPHEMERIS FOR GREENWICH MEAN TIME

1924		True α			True δ			log Δ	Br.
Jan.	8.5	2^{h}	54^{m}	$20^{s}.7$	$+1°$	01′	40″	9.8978	0.38
	9.5		56	26.3		01	49		
	10.5	2	58	32.4		02	17		
	11.5	3	00	39.0		03	05		
	12.5		02	46.1		04	11	9.9162	
	13.5		04	53.7		05	35		
	14.5		07	01.6		07	17		
	15.5		09	10.0		09	15		
	16.5		11	18.9		11	30	9.9344	0.31
	17.5		13	28.1		14	00		
	18.5		15	37.7		16	44		
	19.5		17	47.7		19	42		
	20.5		19	58.0		22	53	9.9524	
	21.5		22	08.7		26	17		
	22.5		24	19.7		29	53		
	23.5		26	31.0		33	41		
	24.5		28	42.7		37	39	9.9702	0.26
	25.5		30	54.6		41	48		
	26.5		33	06.8		46	06		
	27.5		35	19.2		50	34		
	28.5		37	31.9		55	11	9.9879	
	29.5		39	44.8	1	59	57		
	30.5		41	58.0	2	04	50		
	31.5	3	44	11.5	+2	09	51		
Feb.	1.5	3^{h}	46^{m}	$25^{s}.2$	$+2°$	14′	58″	0.0053	0.21
	2.5		48	39.2		20	12		
	3.5		50	53.4		25	32		
	4.5		53	07.8		30	58		
	5.5		55	22.5		36	29	0.0225	
	6.5		57	37.4		42	04		
	7.5	3	59	52.4		47	44		
	8.5	4	02	07.6		53	27		
	9.5		04	23.1	2	59	14	0.0395	0.17
	10.5		06	38.8	3	05	04		
	11.5		08	54.6		10	57		
	12.5		11	10.6		16	52		
	13.5		13	26.7		22	48	0.0563	
	14.5		15	43.0		28	46		
	15.5		17	59.3		34	45		
	16.5		20	15.8		40	45		
	17.5	4	22	32.3	+3	46	44	0.0727	0.14

Brightness November 21 = 1.00

Van Biesbroeck estimated the magnitude on November 28 to be 13.5.

SOPHIA H. LEVY,
C. S. YU.

BERKELEY ASTRONOMICAL DEPARTMENT,
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A STUDY OF THE VARIABLE STAR SX HERCULIS

1. Spectrographic Observations

It was announced by the writer in *Publ. A.S.P.*, **34**, 171, 1922, that spectrograms of the variable star SX *Herculis* showed bright hydrogen lines. As the spectrum is classified in the *Henry Draper Catalogue* as K2, without any remarks, it seemed probable that the bright lines were variable in intensity. This supposition was soon confirmed by further observation.

In the meantime additional facts about this star have been published by Shapley and Jordan in *Harvard Bulletin*, No. 774. It is stated there that spectrograms taken on July 9, 1899, May 28, 1902, and April 30, 1914, show no bright lines, but that these do appear on plates taken on June 23, 1898 and May 16, 1904.

Spectrographic observations of this star with a single light-prism spectrograph attached to the 36-inch refractor, were continued at the Lick Observatory until September 19, 1922; after that date the quartz slitless spectrograph of the Crossley reflector was used. During a short stay at the Mt. Wilson Observatory the writer was allowed to use the 10-inch refractor with objective prism, while Dr. Adams also consented to have a spectrogram taken with the 100-inch reflector.

As during the summer my main program consisted of observing spectrographically a number of proper-motion stars, not much time could be devoted to the variable. Accordingly most plates were taken with small dispersion and very short exposure, and could only serve the purpose of showing the presence or absence of bright lines. They could not be used for the determination of the radial velocity.

In Table I is given a list of all the observations, together with a description of the principal character-

Table I

1922				
May 24	36″ refr.	12″ cam. ptg.	$H\beta$, $H\gamma$, $H\delta$ strong.	+16 km./sec.
25	36″ refr.	12″ cam. ptg.	$H\beta$,$H\gamma$, $H\delta$ strong.	
27	36″ refr.	12″ cam. ptg.	$H\gamma$, $H\delta$ strong, $H\beta$ rather weak.	
29	36″ refr.	6″ cam. ptg.	$H\beta$, $H\gamma$ overexposed, $H\delta$, $H\epsilon$, $H\zeta$ strong.	
31	36″ refr.	16″ cam. ptg.	$H\beta$, $H\gamma$, $H\delta$ strong.	+14
June 9	36″ refr.	16″ cam. ptg.	$H\beta$, $H\gamma$, $H\delta$ strong.	+14
24	36″ refr.	6″ cam. vis.	$H\alpha$, $H\beta$ invisible, D lines weak.	
25	36″ refr.	6″ cam. ptg.	No bright lines visible, plate underexposed.	
26	36″ refr.	16″ cam. ptg.	No bright lines visible, plate underexposed.	
27	36″ refr.	16″ cam. ptg.	$H\beta$, $H\gamma$ very weak, $H\delta$ invisible.	
Aug. 2	36″ refr.	6″ cam. vis.	$H\alpha$, $H\beta$ invisible, D lines weak, spectrum banded.	
18	36″ refr.	6″ cam. ptg.	$H\beta$ bright, class Mb spectrum.	
21	36″ refr.	6″ cam. ptg.	$H\beta$ bright, class Mb spectrum.	
21	36″ refr.	6″ cam. vis.	$H\alpha$, $H\beta$ bright, class Mb spectrum.	
23	36″ refr.	6″ cam. vis.	$H\alpha$, $H\beta$ bright, D lines weak, Mb spectrum.	
Sept. 2	10″ refr.	Obj. prism	$H\beta$, $H\gamma$, $H\delta$ bright.	
3	100″ refl.	18″ cam.	$H\beta$, $H\gamma$, $H\delta$ bright, Class K spectrum.	+22
19	36″ refr.	6″ cam. ptg.	$H\beta$, $H\gamma$, $H\delta$ bright.	
30	Crossley quartz slitless		$H\beta$, $H\gamma$, $H\delta$ bright.	
Oct. 6	Crossley quartz slitless		$H\beta$, $H\gamma$, $H\delta$ just visible.	
12	Crossley quartz slitless		No bright lines visible, probably $H\beta$ absorption line.	

istics of the spectrum. With the single-prism spectrograph employed at the Lick Observatory the dispersions for the various cameras are:

16 inch camera: 58 A per mm at Hγ
12 inch camera: 76 A per mm at Hγ
6 inch camera: 150 A per mm at Hγ

For the quartz slitless spectrograph and the 100-inch reflector spectrograph these values are respectively 150 A and 36 A.

The relative intensities of the hydrogen lines have not been given, as these depend largely on the observing conditions (*e.g.*, kind of plates used, position of the collimator and the use of a photographic correcting lens). All that can be said is, that the relative intensities do not change very much.

We gather from the data in Table I that bright hydrogen lines were present from May 24 until June 27 when they were very weak. They were absent on August 2, present between August 18 and October 6 and had disappeared again by October 12.

The observed radial velocities in the last column give no reason to suspect variability of velocity. We can therefore adopt as the probable value the weighted mean, +18 km/sec.

2. COMPARISON WITH PHOTOMETRIC DATA

It may be recalled that the light variations of SX *Herculis* have a period of about 100 days; there is however considerable difference in the light elements derived by different observers at different epochs. It therefore seems advisable to compare our spectrographic observations with photometric observations that were made simultaneously, or at least not more than a few periods earlier or later. Fortunately we have visual light estimates made by Messrs. Peltier and Waterfield[1] between July 19 and October 17, 1922, which cover the latter half of the spectrographic observations and in particular the time of reappearance of the bright lines.

From the observations we deduce that a minimum occurred about J. D. 2423275 = August 8 and a maximum about J.D. 2423310 = Sept. 12, 1922, or perhaps a few days later. (This is difficult to decide as the light curve is so flat at the maximum). We recall that bright lines were present from J. D. 2423199 to −3233, were invisible at −3269, were present from −3285 − −3334, and were invisible again at −3340. Reduced to the neighborhood of the minimum at 2423275 we get:

Bright lines still visible at J.D. 2423233
invisible from −3240 − −3269
again visible from −3285 on

At the same time the spectral class, which appeared to be a quite normal K2 on May 31 and September 3 (J.D. 2423206 and −3301), was distinctly of Class M from August 2 till August 23. It therefore seems that bright lines develop in the spectrum very shortly after minimum and disappear some thirty to forty days before the next minimum. The spectral class seems to vary from K2 in maximum to Mb in minimum.

The two Harvard observations of bright hydrogen lines were made 3 and 7 days before maximum whereas the bright lines were not visible 70, 34, and 29 days after maximum according to Jordan's elements. In the present investigation bright lines were seen at the latest about 30 days after maximum, which is not inconsistent with the Harvard observations.

3. RE-DISCUSSION OF VISUAL OBSERVATIONS AND LIGHT ELEMENTS

The following elements for the light variation of this star have been published:

Max. = J.D. 2418090.5 + $100^{d}.55$ E M − m = $54^{d}.6$ Luizet[2]
2419884 + 99.6 E 50 Luyten[3]
2414672 + 102.8 E Jordan[4]

Luizet's material consisted of 7 maxima and 9 minima derived from 148 observations made in the years 1908-1911. The writer's elements were based on the same material with the addition of 6 maxima and 6 minima derived from 75 observations made during 1917-1919. As this second set of maxima was not used in the derivation of Luizet's formula it is not surprising that their representation is not so good as by the writer's formula. Jordan's elements rest on 172 photographic observations made throughout the interval from 1891-1922, or, in the mean, 6 observations per year. It cannot be expected therefore that these photographic elements should represent the visual observations of Luizet and Luyten very accurately. This may be seen from Table II where all the published maxima have been collected and compared with the three formulae given above.

TABLE II

Max. J.D.	E	O−C	E_1	O−C_1	E_2	O−C_2	E_3	O−C_3
241 8091	0	$+1^{d}$	−18	0^{d}	33	$+27^{d}$	−21	$+9^{d}$
8198	1	+ 7	−17	+ 7	34	+31	−20	+13
8483	4	−10	−14	− 7	37	+ 7	−17	− 9
8590	5	− 3	−13	+ 1	38	+12	−16	− 5
8889	8	− 6	−10	+ 1	41	+ 2	−13	−14
9008	9	+13	− 9	+20	42	+18	−12	+ 3
9194	11	− 3	− 7	+ 7	44	− 1	−10	−16
Interval of 21 or 22 periods								
242 1372	33	−37	+15	− 6	65	+18	+11	+10
1471	34	−38	+16	− 7	66	+14	+12	+ 6
1574	35	−36	+17	− 3	67	+14	+13	+ 7
1671	36	−39	+18	− 6	68	+ 9	+14	+ 1
1774	37	−37	+19	− 2	69	+ 9	+15	+ 2
2071	40	−41	+22	− 4	72	− 2	+18	− 9
Interval of 12 periods								
3310	52	− 9	+34	+40	84	+ 3	+30	0

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[1] *Pop. Astr.*, Oct.-Dec. 1922.

[2] *Astr. Nach.*, **190**, 342, 1912.

[3] *Ann. Leiden.*, **13**, 2, 40, 1922; also *Dissertation*, Leiden, 1921.

[4] *H.B.*, **774**, 1922.

The writer's elements evidently do not represent the light variations at the present time. To obtain the smallest residuals for the first two formulae it has been necessary to assume that 22 periods elapsed between J.D. 2419194 and 2421372; for the last formula 21 had to be taken. From a comparison of the three series of residuals we gather that the third period, 102.8 days, is probably nearest to the truth, although a correction would have to be applied to the zero epoch. A least-squares solution, using all 14 maxima and adopting 21 for the number of periods elapsed between J.D. 2419194 and 2421372 yields the following elements:

$\text{Max.} = 2420235(\pm 2.5) + 102^{\mathrm{d}}5(\pm 0^{\mathrm{d}}13)\ E$ (errors are mean errors).

In the last column of Table II are given the residuals corresponding to these elements, which seem quite satisfactory. However, the question whether or not the period is subject to secular variations seems still open.

4. Considerations Relating to the Type of Light Variations and the Distance of the Variable

In regard to the light curve it may be mentioned that Luizet found the minima rather sharply defined and the maxima very broad; in fact the star often remained constant in maximum brightness for a month and a half. This same feature of the light curve is shown by the recent observations of Peltier and Waterfield. The writer himself found the light curve more or less resembling a sine curve, *i.e.*, both maxima and minima rather flat. Corroboration of this is also afforded by the fact that the value of M−m of 50 days is very nearly half the period. In *H.B.* **774**, however, it is stated that the photographic light curve resembles very closely that of the brighter *Cepheid* variables in the Magellanic Cloud. In *H.C.* No. **237** the photographic light curve is illustrated and shows a value of M−m of $\frac{44}{127} = 0.35$ of the period as compared with almost 0.50 as derived from visual observations.

Some of the main features of *Cepheid* variation are perhaps that the range in magnitude and the period are almost perfectly constant (disregarding very slow secular changes, such as that found by Hertzsprung in *δ Cephei*[5]).

Both Luizet and the writer found the magnitudes at maximum and minimum varying for SX *Herculis*, while in *H.B.* No. **774** it is stated that "the photographic range is from $9^{\mathrm{m}}45$ to $10^{\mathrm{m}}30$, although several maxima fall outside these limits." The mean residual without regard to sign, as given in the last column of Table II is 8 days, which is larger than seems compatible with typical *Cepheid* variation. Nor does it seem possible to explain all these discordances by errors in the observations. In particular this seems impossible for the two maxima at J.D. 2419194 and at 2421372, the interval between which differs 26 days from the nearest integral number of periods.

The well known galactic *Cepheids* all have spectra clustering around G, and bright lines have not been observed in them. They have been observed only in the peculiar star W *Virginis*. The variable SX *Herculis* with its galactic latitude of +44° and its spectral class varying between K2 and Mb, with variable bright lines, therefore seems to differ somewhat from the average *Cepheids*, in properties other than the period.

In the time of reappearance of the bright lines SX *Herculis* resembles the long period Md variables.[6] In those stars however the relative intensities of the lines change considerably, whereas in our variable not much of a change was noticed.

The length of the period of SX *Herculis* lies between that of the *Cepheids* and the long period variables. By having a small range it seems to be in a class with such stars as V *Canum Venaticorum* and AF *Cygni*, rather than with stars like X *Camelopardalis*, X *Aurigae*, R *Virginis*, SS and T *Herculis* and R *Vulpeculae*, all of which have intermediate periods but a fairly large range.

From the foregoing considerations it appears doubtful whether SX *Herculis* can be classed as a *Cepheid* variable; in any case as stated in *H.B.* **774** the period-luminosity curve cannot be applied for determining its absolute magnitude without first establishing its validity for such long periods. SX *Herculis*, as has just been noted, is intermediate between the *Cepheids* and the Md variables and it is well known that the latter variables do not fit on the period-luminosity curve. For these stars Lundmark[8] has, from data collected by Gyllenberg[9] and Merrill[10] derived an absolute magnitude at maximum of $-2^{\mathrm{m}}8$, but this value seems a little too high. Shapley's estimate of the visual absolute magnitude of SX *Herculis*, on the other hand is about -7^{m} corresponding to a parallax of $0''0001$. Shapley states that "it is very doubtful if the ordinary characteristics of *Cepheid* variation hold generally for stars of such long period." (They *do* seem to hold for the stars with these long periods situated in the Magellanic Cloud.)

A different estimate for the distance of this variable may be obtained by applying the scheme used by Lundmark and the writer[11] to compute parallaxes for stars of known spectrum and proper motion. The material for the derivation of this last quantity is collected in Table III.

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[5] *Astr. Nach.*, **210**, 17, 1919.

[6] Merrill, *Mt. Wilson Contributions*, No. **200**.

[8] *Publ. A.S.P.*, **34**, 196, 1922.

[9] *Arkiv. for Mat. Astr.*, **14**, 5, 1919.

[10] *Mt. Wilson Report*, 1920.

[11] *Lick Obs. Bull.*, **10**, 153, 1922.

TABLE III

Catalogue	Epoch	R.A. 1900.0	Dec.
Lal. 29428	1794.9	$16^h\ 03^m\ 14\overset{s}{.}68$	$+25°\ 10'\ 37\overset{''}{.}7$
$W_2 16^h$ 8–9	1827.5	15.05	35.6
Par_2 20182	1859.0, 62.9	14.93	35.4
Cbr. E 7486	1875.6	14.89	36.1
Par_3 20182	1875.7, 77.0	14.79	36.0
Oxf. Astr.[1]	1908.4	14.93	34.5
Grw_{1910} 7053	1908.8	14.77	34.5

---

[1] Mean position of +25° 46649 and +26° 38230. The positions from Weisse and Greenwich 1910 have been corrected by means of the systematic corrections given in the introduction of the Greenwich 1910 Catalogue.

Owing to the small weight that can be attached to the first two positions only an estimate of the proper motion can be made. A graphical solution gives:

$$\mu_\alpha = -0\overset{s}{.}0007,\ \mu_\delta = -0\overset{''}{.}027, \text{ or } \mu_{tot} = 0\overset{''}{.}028$$

In the Greenwich 1910 catalogue values of $-0\overset{s}{.}0022$ and $-0\overset{''}{.}038$ respectively are given, but these seem rather high.

If the visual magnitude at maximum is adopted as $7\overset{m}{.}8$ then

$H = \mathrm{m}+5+5 \log \mu = +5\overset{m}{.}0$, and $M_H = +1\overset{m}{.}1$.
$M_S = +0\overset{m}{.}8$ (*Publ.A.S.P.*, **34**, 156, 1922)
Thus we have $M_{S,\,H} = +0\overset{m}{.}9$ and $\pi_{S,\,H} = 0\overset{''}{.}0042$

This gives for the tangential velocity about 31 km/sec. Combining it with the radial velocity of 18 km/sec we obtain a space velocity of about 36 km/sec. The radial velocity alone would have made a space velocity of 36 km/sec plausible. On the basis of a parallax of $0\overset{''}{.}0001$ the tangential velocity would be of the order of 1300 km/sec. This parallax would place the star 10,000 parsecs away from us in radial distance and 7000 parsecs from the galactic plane; that is to say in a region of space where according to Kapteyn[12] the star density is negligibly small.

WILLEM J. LUYTEN.

MT. HAMILTON,
December 15, 1922.

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[12] *Mt. Wilson Contributions*, No. 230.

SPECTRAL CLASSES AND HYPOTHETICAL PARALLAXES OF ONE HUNDRED FAINT STARS OF LARGE PROPER MOTION.

The relative importance of faint stars of large proper motion in statistical investigations makes it desirable to accumulate as much observational data as possible for these stars. One of the principal desiderata and the one most easily obtained is the spectral class, for the determination of which a spectrograph of small dispersion suffices. The determination of the parallax, however, or of the radial velocity requires observations extended over a much longer period or observations made with a larger-dispersion spectrograph and consequently longer exposures.

The stars for the present observing program were selected from the list of stars with proper motions exceeding half a second annually and include all stars for which no previous determination of spectral class was known to the writer and which were within reach of the 36-inch telescope.

The instrument employed was a single light-prism spectrograph and short camera attached to the 36-inch refractor of the Lick Observatory, giving a dispersion on the plate of six millimeters from $H\beta$ to K. Hydrogen-helium was used as comparison almost invariably. All observations were secured between April 20 and December 20, 1922. The magnitudes of the stars varied from 8.5 to 12.3, requiring exposure times ranging from thirty minutes up to twenty hours. The total number of successful exposure hours was 300.

When beginning the observations the writer was confronted with the difficult choice of, (*a*) using a comparatively narrow slit, making very long exposures, and obtaining two good plates of each star, in order to be able to measure at least an approximate radial velocity, or, (*b*) using a wider slit and securing only one plate for each star with shorter exposures so that the spectrum shown would just be strong enough for classification.

In view of the fact that procedure (*a*) would yield only a few results, method (*b*) was adopted. An indication that this was the right choice may perhaps be found in the fact that in only six months' time the writer found some thirty-five new dwarf M stars.

The classification was effected by means of comparison with spectra of Harvard standard stars taken under the same conditions. The classification is therefore presumably the same as that of the New Henry Draper Catalogue.

It has been shown by Lundmark and the writer, that a fairly reliable prediction of the parallax of a star may be obtained from the knowledge of the spectral class and the proper motion.[1] The procedure has been described at length in our previous papers[2] and need not be repeated here. As numerical values of the necessary constants those published by the writer in *Publ. A.S.P.* June, 1923, were used.

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[1] *Amer. Astron. Soc.*, Dec., 1922.
[2] *Lick Obs. Bull.*, **10**, 153, 1922; **11**, 33, 1923.
Pop. Astr., Aug. 1923.
Publ. A.S.P., **35**, 209, 1923.

The results of observation and computation are shown below in Table I. Column 1 gives the current number in the "List of stars whose proper motions are not less than 0″.50 annually." Column 4 gives the spectral class as determined from the observations, column 8 the quantity $H = m + 5 + 5 \log \mu$, column 9 the computed absolute magnitude, and column 10 the adopted parallax. The other columns need no explanation.

The parallax has not been inserted in the case of those stars to which our scheme is not applicable, or for those companions to bright stars for which a reliable trigonometric parallax has been determined.

TABLE I

10	BD+40° 45	9.4	K2	0^h	11^{m}8	+40°	23′	0″.58	13.2	7.5	0″.042	
12	Comp Bo 187	10.7	Mb		12.7	+43	28	2.89	18.0	....	....	1
18	BD+66° 34	9.7	Ma		26.2	+66	42	1.78	16.0	9.8	.105	
22	Wolf 1056	11.4	K0		33.5	+30	04	1.69	17.5	7.6	.017	2
35	Wolf 28	12.3	F		43.9	+ 4	55	3.01	19.7	....	....	3
37	Wolf 33	11.0	Ma		45.3	+57	45	1.58	17.6	10.3	.072	
43	BD+61° 195	11.0	Ma		56.3	+61	48	0.72	15.3	9.6	.052	
46	Hels 914	8.7	K2	1	00.3	+63	24	1.55	14.7	7.9	.071	
69	Wolf 110	11.4	K-M		57.4	+ 5	14	2.43	18.3	9.6	.043	
70	BD+44° 422	9.9	K5	2	00.7	+44	43	0.51	13.4	8.1	.044	
75	BD+2° 348	10.5	Ma		07.4	+ 3	10	2.60	18.1	10.3	.091	
88	Comp Lpz II 961	11.5	Mb		30.8	+ 6	25	2.32	18.6	....	....	
103		10.2	Ma	3	02.8	+45	22	0.52	13.8	9.7	.079	
113	BD+66° 268	9.2	G5		21.8	+66	26	1.67	15.5	7.4	.044	
134	BD−21° 784	9.1	K5	4	02.2	−21	06	0.79	13.6	8.2	.066	
141	Cbr M 1885	8.6	K0		27.9	+55	13	0.64	12.7	6.6	.040	
150	BD+19° 869	10.5	K5	5	07.0	+19	37	0.71	14.8	8.5	.040	
153	BD+44° 1142	10.2	K		07.7	+44	26	0.67	14.3	7.8	.033	
175	Cbr E 2935	8.9	K2		59.7	+26	34	0.50	12.4	7.2	.046	
179	BD+47° 1276	9.5	K0	6	09.2	+47	07	0.52	13.4	6.8	.029	
182		10.5	K2		21.7	+35	59	0.53	14.1	7.8	.029	
183	Cbr E 3265	8.7	G5		22.9	+27	05	0.50	12.2	6.3	.033	
185	BD+17° 1320	9.7	Ma		31.4	+17	38	0.88	14.4	9.4	.087	
189		10	F		40.9	+37	39	0.95	14.9	[5.7]	.014	
191	Wolf 294	10.0	Ma		48.4	+33	24	0.84	15.6	9.4	.076	
200	BD+33° 1505	9.3	K5	7	13.0	+33	02	0.57	13.1	8.0	.055	
203	BD +37° 1748	9.5	K0		31.6	+36	57	0.87	14.2	6.9	.030	
210	Cbr M 2950	8.6	K0		40.8	+53	55	0.56	12.1	6.5	.038	
214		11.0	K2		50.8	+40	19	0.60	14.9	8.0	.025	
229	BD+33° 1694	9.2	K2	8	18.9	+32	57	0.69	13.4	7.5	.046	
230	BD+46° 1405	9.5	K0		22.5	+46	15	0.57	13.4	6.8	.029	
231	BD+67° 552	9.3	K7		27.4	+67	40	1.10	14.7	8.9	.083	
239	BD+37° 1912	9.5	K2		43.0	+36	54	0.56	13.5	7.5	.040	
244	Be B 3609	9.0	F0		52.1	+20	52	0.73	14.1	5.3	.018	
251	BD+77° 361	9.2	K2	9	06.4	+77	39	1.06	14.7	7.9	.055	
258	BD+36° 1970	9.3	K0		25.8	+36	47	0.56	13.0	6.7	.030	
268	Hels 6113	8.5	Ma		48.8	+63	17	0.60	12.9	9.0	.125	
270	Wolf 335	11.2	M		55.0	+32	48	1.20	16.6	10.0	.057	
274	BD+10° 2122	9.3	K0	10	07.9	+10	04	0.63	13.3	6.8	.032	
278	BD+46° 1635	8.8	K0		25.5	+46	03	0.84	13.4	6.8	.040	
283	Be C 1500	9.5	K5		51.0	+70	08	0.63	13.7	8.2	.055	
284	Bo 7830	9.0	K2		51.4	+42	26	0.74	13.4	7.5	.050	
299	Nic 3220	8.8	K2	11	12.2	− 1	26	0.53	12.4	7.2	.048	
305	BD+15° 2325	9.5	K0		17.2	+15	00	0.54	13.5	6.8	.029	
306	Wolf 386	10.5	Ma		18.6	+ 9	07	1.05	15.6	9.7	.069	
312	Wolf 397	9.7	K8		23.3	+ 8	06	1.16	15.3	9.2	.080	
317	BD+40° 2442	10.1	K2		31.3	+39	45	0.60	14.0	7.7	.033	
333	Wolf 406	10.5	K2	12	03.3	+ 0	03	1.07	15.7	8.2	.034	
337	BD+29° 2279	9.5	K8		14.5	+28	56	0.64	14.0	8.8	.073	
346	Lpz II 6152	8.8	Ma		26.3	+ 9	23	0.96	14.2	9.3	.125	
397	Nic 3625	9.0	K5	13	36.8	+ 0	23	0.54	12.7	7.9	.060	
402	BD−5° 3763	9.0	K0		42.2	− 5	37	0.58	12.8	6.7	.034	
410	BD+34° 2476	9.3	A5		54.8	+34	23	0.54	13.5	[4.0]	.01	2
411		10.4	K5		54.8	+25	44	0.53	14.1	8.3	.036	

412	Bo 9239	8.8	Ma	13^{h}	$58^{m}5$	+46°	49′	0″61	12.7	8.9	0″105	
415	BD+81° 465	9.5	Ma	14	10.4	+80	51	0.58	13.6	9.2	.087	
429	BD+24° 2735	9.5	K2		23.3	+24	17	0.50	13.2	7.5	.040	
433	Lei 5231	9.0	K5		30.9	+34	11	0.76	13.6	8.2	.069	
440	BD+6° 2932	9.5	G		38.5	+ 6	15	0.93	14.3	[6.5]	.025	5
442	Be A 5335	8.9	K5		41.7	+16	56	0.97	13.8	8.2	.072	
450		10.8	Ma		52.0	+72	05	0.92	15.6	9.6	.057	
455	Cbr E 7086	9.2	K0	15	03.1	+25	18	0.96	14.1	6.8	.033	
456	BD+32° 2547	9.5	F5		03.6	+32	46	0.59	13.4	[5.0]	.01	
463	Str 5325	9.2	K2		08.8	− 3	26	0.69	13.4	7.5	.046	
466	BD−7° 4003	9.2	Md		14.2	− 7	21	1.33	14.8	9.5	.115	
489	BD+35° 2774	9.5	K	16	02.9	+34	55	0.64	13.7	7.6	.042	
495	Comp Chri 2448	10.6	Ma		16.6	+67	30	0.50	14.1	....	....	
497	Gron Star	10.7	Mb		21.1	+48	36	1.23	16.2	11.3	.133	
501	BD−12° 4523	9.5	Ma		24.8	−12	24	1.24	15.0	9.6	.105	
503		10.0	K0		25.2	+44	55	0.75	14.4	6.9	.024	
513	Comp W Ott 5811	11.4	M		49.6	− 8	08	1.23	16.9	....	....	
515	BD+25° 3173	9.4	Ma		54.1	+25	55	0.52	13.0	9.0	.083	
536		10.6	Ma	17	16.7	+41	50	0.88	15.3	9.6	.063	
545	26 Drac C	10.5	Ma		34.5	+61	45	0.58	14.3	....	....	
551	BD+43° 2796	9.5	Ma		40.9	+43	26	0.62	13.5	9.2	.087	
553	Comp μ Her.	9.8	M		42.5	+27	47	0.82	14.4	....	....	
570	BD+45° 2743	9.5	K5		32.4	+45	39	0.58	13.3	8.1	.052	
574	Hels 9945 B	9.4	Mb	18	41.7	+59	29	2.31	16.2	....	....	
576	Be A 7030	9.0	K2		44.5	+17	20	0.58	13.2	7.5	.050	
579	Be A 7153	9.5	K0		56.4	+18	57	0.62	13.6	6.8	.028	
582	17 Lyrae C	11.3	M	19	03.8	+32	20	1.66	17.4	11.8	.125	
587	Bo 12845	8.8	G5		15.7	+41	28	0.66	12.9	6.5	.033	
590a	Bo 12989	9.0	K2		23.6	+49	15	0.85	13.7	7.5	.050	4
592	BD+35° 3659 sf	9.5	A5		27.6	+35	57	0.56	13.2	[4.0]	.01	2
610	Wolf 1130	11.4	M	20	02.7	+54	10	1.48	17.2	11.7	.115	
628		9.4	Ma		41.5	+44	08	0.50	12.9	9.0	.083	
630	Wolf 891	10.5	K5		48.8	− 3	08	0.79	15.0	8.6	.042	
637	Wolf 901	11.4	M		54.1	+ 3	11	1.11	16.6	10.0	.052	
639		9.7	Md		56.2	+39	41	0.67	13.8	9.2	.079	
667	BD+27° 4120	10.4	Ma	21	33.5	+27	16	0.50	13.9	9.3	.060	
680	Wolf 1143	10.8	F		50.8	+32	10	0.73	15.1	[6.]	.01	
683	BD+9° 4955	10.5	K0		56.0	+ 9	28	0.51	14.0	6.8	.018	
686	Be B 8548	8.8	K0	22	05.9	+22	18	0.59	12.7	6.6	.036	
688	BD+30° 4633	10.4	K2		07.7	+31	05	0.53	14.1	7.7	.029	
701	BD+53° 2911	9.5	K2		28.7	+53	16	1.48	15.7	8.2	.054	
707	BD+43° 4305	9.5	Md		42.5	+43	49	0.86	14.2	9.4	.096	
709	W Ott 8161	8.7	K0		50.6	− 8	21	0.54	12.3	6.6	.038	
729	Wolf 1039	11.4	Ma	23	29.0	− 0	21	1.44	17.0	10.1	.055	
731		10.8	Ma		30.8	+41	25	0.72	15.1	9.5	.055	
749	Comp Bo 18443	10.2	Ma		59.9	+45	14	0.86	14.9	....	....	

[1] For all M stars see also *Publ. A.S.P.*, **34**, 342, 1922.

[2] cf. *Publ. A.S.P.*, **34**, 356, 1922.

[3] cf. *Publ. A.S.P.*, **35**, 175, 1923.

[4] *B.A.N.*, **1**, 162, 1922.

[5] Indications of large negative radial velocity.

TABLE II

Wash 6520	18^{h}	$00^{m}5$	−16°	42′	9.2	B	No proper motion; probably error of 2^{s} in Mu I.
Comp α Lyr		33.7	+38	41	10	K	Optical companion.
BD+17° 3719		43.6	+17	17	9.4	A	Observed instead of Be A7030.
BD+44° 3567	20	41.9	+44	34	9.5	A	Observed instead of No. 628.
	21	41.5	+43	51	11.3	A	No trace of proper motion, *not* Furuhjelm 56.
BD+57° 2514	22	18.8	+57	27	10.4	F5	cf H.B. 786.
BD+56° 2779		23.8	+56	36	10.8	K	cf H.B. 786.

In Table II are collected the data for those stars which were observed incidentally or by misidentification of stars on the regular program.

The writer wishes to express his deep appreciation for the observing facilities so liberally granted by Director Campbell. Thanks are due to Mr. W. H. Wright for the interest he took in the work and for the many valuable suggestions and practical hints he gave throughout.

WILLEM J. LUYTEN.

October, 1923.

ERRATA AND ADDENDA TO THE LIST OF PROPER MOTION STARS PUBLISHED IN LICK OBSERVATORY BULLETIN No. 344.

Since the publication of *Lick Observatory Bulletin* No. 344, additional material has been published elsewhere, and stars previously overlooked have been found, which make a revision of that list desirable.

In Table III are given those stars which should be added to the previous list. The arrangement of the table is exactly the same as that of the earlier one and needs no further comment.

TABLE III

No.	H.D.	Name	Mag.	Sp.	R.A.			Dec.		μ	ρ	Source	H
93a		Wolf 1323	*10*		2	45	51	+34	00.0	1″.42	125°.	Letter from	16.3
106a		Wolf 1324	*11*		3	09	56	+37	45.2	1.36	156.	Dr. Max Wolf	17.1
107a		Wolf 1325	*11*			11	38	+37	53.9	0.78	142.	" " "	15.9
132a		Wolf 1322	*13.5*			53	45	+25	48.7	0.95	100.	" " "	18.6
178a		Comp 71 *Ori*	11.2		6	08	52	+19	11.1	0.947	194.6	A.N. **185**, 213	16.1
225a		BD+54° 1216	9.3		8	11	47	+54	26.9	0.650	180.	Hamb.	13.4
297a	98078	Be B 4228	8.2	G5	11	11	50	+21	51.8	0.553	205.4	A.N. **198**, 199	11.9
361a	111513	Hels 7321	7.3	G0	12	44	41	+61	55.0	0.546	281.0	Hamb.	11.0
452a	132683	Harv II 5259	10.0	K5	14	55	18	−10	43.5	0.498	180.	H.A. **81**	13.5
579a			15		18	57	41	−13	42.0	0.8	225.	H.B. **786**	19.5
590a	183255	Bo 12989	9.0	K2	19	23	39	+49	14.6	0.845	33.	B.A.N. **1**, 162	13.6
600a	189340	Harv II 7037	5.9	F8		54	21	−10	13.2	0.495	221.	H.A. **81**	9.4
618a	194598	Lpz II 10078	8.5	F5	20	21	22	+ 9	08.8	0.554	169.6	Hamb.	12.2
630a		Lpz I 8218	8.7			50	17	+12	46.5	0.667	54.6	Hamb.	12.8
744a		Oxf. Astr.+26° 41	11.4		23	56	50	+25	27.9	0.698	297.1	M.N. **83**, 68	15.6

Nos. 225 and 538 in the previous list should be cancelled, as the proper motion there given is erroneous. It appears to be insensible from examination of plates in the blink microscope at Harvard.

For Nos. 170 and 435-6 in that list the sign of the radial velocity should be changed from + to −.

No. 307 is a double star, 11^h, 22 in Innes's Reference Catalogue; the components have magnitudes 8.3 and 8.9. No. 696 is Innes 1055, of *Union Observatory Circular* No. **8**.

For No. 187, H should read 14.0 instead of 14.6; for No. 531 it should be 11.3 instead of 10.3.

For No. 17 column proper motion read 2″.240 instead of 2″.268; for No. 682 read 4″.696 instead of 4″.705.

WILLEM J. LUYTEN.

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Issued March 19, 1924.

Ackd.

UNIVERSITY OF CALIFORNIA PUBLICATIONS

ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 352

THE ORBIT OF THE SPECTROSCOPIC BINARY δ TRIANGULI

The variability of the radial velocity of δ *Trianguli* (1900.0 $\alpha = 2^h10^m8$, $\delta = +33°46'$, visual magnitude 5.07, spectral class G0) was discovered by Miss A. M. Hobe[1] from the measures of four plates taken in 1910. From September 5, 1922, to January 8, 1923, twenty-three spectrograms of this star were secured with the three-prism Mills spectrograph, the average exposure-time on a Seed 60 plate being three hours. All the plates were measured on a Gaertner engine, in general twenty to twenty-six lines being measured. As the plates were of practically the same density the values of the radial velocity were weighted equally in the least-squares solution of the elements. No trace of the secondary spectrum was observed.

Period:—From a study of the 1922 observations the period was determined to be approximately 9.93 days. With this preliminary value the early observations were employed to deduce a more exact one. Designating these early observations given in Table I as A, B, C, and D, the following values were found.

A	9.9292 days
B	9.9295 days
C	9.9290 days
D	9.9288 days

Weighting these according to the elapsed number of revolutions, shown in Table I, the resulting period of 9.92912 days was adopted. The early observations, which are plotted as barred circles in Fig. 1, were not otherwise used in the derivation of the elements.

Elements:—The graphical method of Lehmann-Filhes[2] was followed in finding the preliminary elements:

$$\text{From the curve: } \left.\begin{array}{l} A = 9.70 \text{ km.}, z_1 = +67.0 \\ B = 8.50 \text{ km.}, z_2 = -71.5 \end{array}\right\} \text{measured by a planimeter.}$$

Period	$P = 9.92912$ days
Time of Periastron Passage	$T = 1922$ September 11.60 G.M.T = J.D. 2423309.60
Eccentricity	$e = 0.069$
Longitude of Apse	$\omega = 28\overset{\circ}{.}2$
Semi-amplitude	$k = 9.10$ km.
Velocity of the System	$\gamma = -5.80$ km.

Considering the period as established, and employing the equations of condition of Schlesinger,[3] the following normal equations resulted:

$$\begin{array}{rrrrrr} +23.000\Gamma & +3.599\kappa & +0.482\pi & +7.846\epsilon & +1.080\tau & +1.320=0 \\ & +12.219 & +0.626 & -0.379 & +0.519 & +3.455=0 \\ & & +10.169 & -0.160 & +9.028 & -0.688=0 \\ & & & +1.791 & +0.066 & -0.288=0 \\ & & & & +0.051 & +0.043=0 \end{array}$$

The solution of the equations yielded the following values of the unknowns:

$$\tau = -1.081,\ \epsilon = +0.201,\ \pi = +1.031,\ \kappa = +0.283,\ \Gamma = -0.052$$

from which are derived the corrections:

$$\delta\kappa = -0.283 \text{ km.},\ \delta\omega = 6\overset{\circ}{.}20,\ \delta e = -0.010,\ \delta\tau = -0.173 \text{ days},$$
$$\delta\gamma = -0.024 \text{ km.}$$

Therefore the final elements with their probable errors are:

$P = 9.92912$	± 0.00009 days
$T = 1922$ September 11.427 G.M.T. = J.D. 2423309.427	± 0.004 days
$e = 0.059$	± 0.012
$\omega = 21\overset{\circ}{.}50$	$\pm 1\overset{\circ}{.}10$
$k = 8.82$ km.	± 0.09 km.
$\gamma = -5.82$ km.	

$$a \sin i = 1{,}200{,}000 \text{ km.}$$

$$\frac{m^3 \sin^3 i}{(m+m_1)^2} = 0.000070\odot$$

The final residuals are given in column 7 of Table I.

The sum of the squares of the residuals was reduced from 3.8006 to 2.6266. The velocity curve (Fig. 1) was drawn according to the final elements, the radii of the circles representing the probable error of a single observation, *i.e.*, 0.31 km.

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[1] *L.O.B.* **6**, —142, 1911.
[2] *A.N.* **136**, 3242.
[3] *Pub. Allegheny Obs.* **1**, 33, 1910.

TABLE I.—OBSERVATIONS OF δ TRIANGULI

					Residuals (O−C)		
No.	Plate	G.M.T.	Phase	Obs. Vel.	Prelim.	Final	Elapsed revolutions
		1910		km.		km.	
A	6692	Aug. 29.905	9.50	−11.0		+0.80	444
B	6751	Sept. 25.815	6.62	+ 2.4		−0.20	441
C	6875	Oct. 26.792	7.81	− 2.9		+0.20	438
		1911					
D	7165	Jan. 22.691	6.35	+ 4.1		+0.80	429
		1922		km.	km.	km.	
1	12490	Sept. 5.9819	0.98	−14.37	−0.10	−0.26	
2	501	9.8918	4.89	+ 1.54	−0.08	+0.14	
3	516	14.0034	9.00	−10.18	+0.04	−0.24	
4	522	21.9771	7.05	+ 0.75	−0.29	+0.05	
* 5	530	27.9679	3.11	− 6.76	+0.74	+0.79	
* 6	536	Oct. 12.7462	7.96	− 4.08	+0.19	+0.16	
7	539	19.9529	5.24	+ 2.60	−0.20	+0.06	
8	543	22.8273	8.11	− 5.06	+0.14	+0.06	
9	546	24.9884	0.34	−13.87	+0.25	−0.01	
10	551	Nov. 16.0030	2.57	−10.56	−0.48	−0.47	
11	553	20.7186	7.21	− 0.28	−0.38	−0.22	
12	555	23.7596	0.33	−13.09	+1.00	+0.75	
13	560	25.9297	2.50	−10.67	−0.30	−0.28	
14	562	26.6428	3.21	− 6.71	+0.18	+0.33	
15	565	28.8665	5.43	+ 2.93	−0.40	−0.07	
†16	568	29.6761	6.24	+ 3.78	+0.19	+0.56	
*17	571	Dec. 3.8251	0.46	−14.05	+0.18	−0.07	
18	572	17.7585	4.47	− 0.59	−0.32	−0.16	
19	575	18.9200	5.63	+ 3.53	−0.12	+0.21	
20	577	19.7462	6.46	+ 3.10	−0.06	+0.17	
21	579	20.8266	7.54	− 1.71	−0.01	+0.10	
		1923					
22	583	Jan. 7.6458	5.50	+ 2.57	−0.88	−0.56	
23	12589	Jan. 8.7969	6.65	+ 2.02	−0.61	−0.26	

*Plate secured by F. J. Neubauer.
†Plate secured by J. H. Moore.

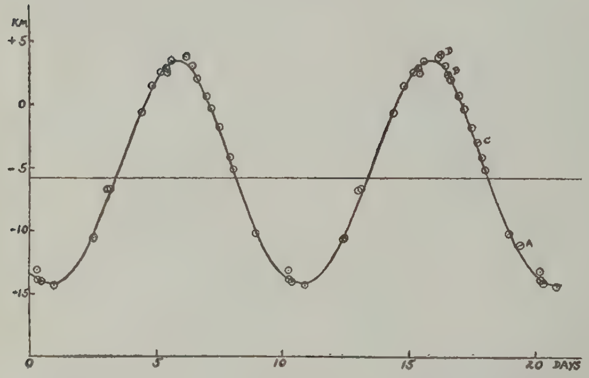

FIG. 1. THE VELOCITY CURVE OF δ TRIANGULI

The spectroscopic absolute magnitude of δ *Trianguli* is 4.8[4] which places the star among the dwarfs. The work of R. F. Sanford[5] and R. E. Wilson[6] shows that "dwarf binaries have shorter periods and smaller eccentricities than do giant stars of the same spectral class." The agreement between the elements of this star and those of the systems investigated by Dr. Sanford is seen from Table II.

TABLE II.—P. AND E. OF DWARF BINARIES, CLASS G

Star	App. Mag.	Sp. Class	Abs. Mag.	P.	e.
OΣ 82	7.0	F9	4.1	$4\overset{\mathrm{d}}{.}0000$	0.60
AOe 12584	8.2	G6	5.4	5.4145	0.000
†Gron. No. 14, *12	8.4	G5	5.5	5.6 . . .	0.04±
δ Trianguli	5.1	G0	4.8	9.92912	0.059
75 Cancri	6.0	G2	4.1	19.4589	0.206
Lal. 13792	7.0	G5	4.8	32.8092	0.080

† Kindly communicated by Dr. Sanford in advance of publication.

J. A. PEARCE.

LICK OBSERVATORY,
August 20, 1923.
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[4] *Mt. Wilson Contributions*, **199.**
[5] *Mt. Wilson Contributions*, **251.**
[6] *A.J.* **33,** 147, 1921.

UNIVERSITY OF CALIFORNIA PUBLICATIONS

ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 353

ELEMENTS AND EPHEMERIS FOR THE MINOR PLANET 1922 MZ = 1913 TC

This asteroid was discovered by Van Biesbroeck at the Yerkes Observatory on November 23, 1922. It was independently found by Wolf at Heidelberg on a plate taken December 14, 1922. A preliminary orbit and ephemeris were computed by Shane and the writer, which appeared in *L.O.B. 347*, 1923, under the designation (Y. O. 5). In a letter addressed to Professor Leuschner in July 1923, Director Frost of the Yerkes Observatory mentions that Stracke thought that the planet might be identical with 1913 TC. This possible identity had been recognized also by Thiele and by the writer. The elements of 1913 TC computed by Cohn from observations by Palisa[1] appeared in *A.N.* **199**, 330, 1914. The object was discovered on October 24, 1913, by F. Kaiser at Heidelberg[2]. The following orbit confirms the suspected identity. The elements closely agree with those by Stracke published in *Kleine Planeten*, 1924, where the number (990) has been assigned. So far the elements by Stracke with assigned number do not seem to have been published in the *Astronomische Nachrichten.*

Nine photographic positions for 1922.0 secured on five different dates at the Yerkes Observatory have now been published in the *Astronomical Journal.*[3] These were utilized to form the following places which have been corrected for aberration and parallax:

	1922 G.M.T.	α 1922.0	δ 1922.0	No. of observations
I	Nov. 23.81953	$4^{h}\ 37^{m}\ 08^{s}.02$	+36° 37′ 51″.1	2
II	Nov. 24.76087	4 36 01.87	36 37 49.9	1
III	Dec. 15.82460	4 12 12.15	35 48 33.4	2
IV	Dec. 22.68832	4 06 17.42	35 17 29.8	2
	1923			
V	Mar. 10.56616	4 42 13.54	+31 16 22.8	2

The following elements were derived from the first, fourth, and fifth of these positions by differential correction of the geocentric distance and of the heliocentric velocities for the middle date, according to Leuschner's method (*Lick Observatory Publications*, Vol. VII), so as to represent the first and fifth places.

ELEMENTS

Epoch	1922 Dec. 22.68832 G.M.T.	
T	1922 May 4.60304	
M	52° 27′ 13″.8	
ω	6 42 14.5	
Ω	354 11 51.9	1922.0
i	8 48 41.2	
φ	12 29 13.7	
μ	813.640	
P	4.36106 years	
log a	0.426382	

CONSTANTS FOR THE EQUATOR 1922.0

$x=r\,[9.999948]\sin[90°\ 58'\ 11''.6+v]$

$y=r\,[9.927390]\sin[00\ \ 24\ \ 37.4+v]$

$z=r\,[9.727012]\sin[02\ \ 22\ \ 41.4+v]$

To check the computation the observations were represented by means of the constants for the equator.

Residuals (O—C)

	$\Delta\alpha\cos\delta$	$\Delta\delta$
I	$-0^{s}.04$	+1″.1
II	−0.05	+0.1
III	−0.30	+9.2
IV	−0.03	+1.1
V	+0.05	+0.5

ELEMENTS AND CONSTANTS FOR THE EQUATOR 1924.0

ω	6° 42′ 14″.6	$x=r\,[9.999949]\sin[90°\ 59'\ 51''.1+v]$
Ω	354 13 32.3	$y=r\,[9.927408]\sin[00\ \ 26\ \ 27.4+v]$
i	8 48 42.2	$z=r\,[9.726962]\sin[02\ \ 23\ \ 54.5+v]$

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[1] *A.N.* **198,** 189, 1914.

[2] *A.N.* **196,** 210, 1913.

[3] *A.J.* **833,** 136, 1924.

EPHEMERIS

1924 G.M.T.	α (True)	δ (True)	log ρ	log r	Mag.
Mar. 29.5	10^h 34^m $17^s.9$	+10° 58′ 21″	0.3674	0.5072	16.2
April 2.5	31 44.5	11 02 04			
6.5	29 34.3	11 04 36	0.3811	0.5078	16.3
10.5	27 41.1	11 04 48			
14.5	26 29.1	11 03 48	0.3964	0.5084	16.4
18.5	25 27.6	11 00 30			
22.5	24 47.5	10 56 01	0.4130	0.5090	16.5
26.5	24 26.7	10 49 15			
30.5	24 27.0	10 41 17	0.4302	0.5094	16.6
May 4.5	24 45.9	10 31 26			
May 8.5	10 25 26.2	+10 20 23	0.4478	0.5099	16.7

The magnitudes in the last column of the ephemeris, and in the comparison below were computed by means of the equations.

$$g = m_0 - 5 \log a\ (a-1)$$
$$m = g + 5\ (\log \rho + \log r)$$

Where m_0 = magnitude at the epoch.

	1913 TC	1922 MZ
m_0	14.7	15.1
g	11.5	11.9

Based on the identity of the two objects, the value of Δg (visual-photographic) is +0.4, which is in fair agreement with the color index for spectral class G_0.

It is a pleasure to acknowledge the verification of the earlier part of the computation by Mr. T. S. Jacobsen.

J. A. PEARCE.

BERKELEY ASTRONOMICAL DEPARTMENT,
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NUMBER 354

INVESTIGATION OF THE ORBIT OF COMET *b* 1922 (SKJELLERUP)

In the concluding paragraph of our article on the orbit of Comet *b* 1922, BULLETIN No. 341, it was indicated that the orbit of this comet is very similar to that of Comet *c* 1902 (Grigg).

The present paper gives the preliminary results of our investigation into the question of the possible identity of the two comets. For this purpose we determined an orbit of Comet *b* 1922 based on the longest available arc. Three normal places were formed from the following ten observations:

	1922 Gr. M. T.	app. α	app. δ	Observer
1.	May 19.23810	120° 55′ 54″.9	+21° 17′ 14″.7	Innes, Johannesburg
2.	May 20.40443	122 22 49.8	+22 21 17.9	Mündler, Königstuhl
3.	May 21.63569	123 59 02.8	+23 32 18.6	Van Biesbroeck, Yerkes
4.	June 28.65024	225 10 45.4	+43 56 11.1	Van Biesbroeck, Yerkes
5.	July 1.73749	231 38 34.6	+41 37 11.7	Barnard, Yerkes
6.	July 2.79343	233 36 38.8	+40 47 41.2	Van Biesbroeck, Yerkes
7.	Aug. 12.62324	268 45 54.2	+14 32 19.1	Van Biesbroeck, Yerkes
8.	Aug. 12.65023	268 46 32.7	+14 31 31.0	Van Biesbroeck, Yerkes
9.	Aug. 13.61725	269 14 19.2	+14 05 33.9	Van Biesbroeck, Yerkes
10.	Aug. 13.65645	269 15 19.8	+14 04 26.3	Van Biesbroeck, Yerkes

The last four are photographic observations.

The resulting normal places are:

	1922 Gr. M. T.	α 1922.0	δ 1922.0
I	May 20.0	121° 52′ 23″.4	+21° 59′ 12″.2
II	July 1.0	230 12 05.1	+42 11 16.3
III	Aug. 13.0	268 56 23.1	+14 21 53.6

The normal dates are the dates corrected for aberration, and the α's and δ's have been corrected for geocentric parallax.

The elements by Merton (*A. N.* 5166) were used as the basis for the computation leading to an orbit to represent the three normal places. Changing these elements according to Leuschner's method for deriving an intermediate orbit to represent the middle place exactly and throw all of the residuals into the two outer places gave the following starting residuals:

		I	III
(o − c)	$\Delta\alpha\cos\delta$	+16″.1	+61″.2
	$\Delta\delta$	− 9.6	−29.1

A differential correction of the intermediate orbit by Leuschner's method to remove these residuals resulted in the following elements:

T = 1922 May 15.22533 Gr. M. T.

$$\left.\begin{aligned}\omega &= 355^\circ\ 03'\ 28''.5\\ \Omega &= 215\ \ 26\ \ 11.3\\ i &= 17\ \ 31\ \ 47.0\end{aligned}\right\}\ 1922.0$$

φ = 44 10 22.7
$\log a$ = 0.467157
$\log q$ = 9.948845
μ = 706″.758
P = 5.02037 years

These represent the outer normal places as follows:

		I	III
(o − c)	$\Delta\alpha\cos\delta$	+0″.7	−1″.4
	$\Delta\delta$	+0.9	−0.4

In the derivation of this orbit the perturbations due to the action of the Earth were taken into account. The comet's nearest approach to the Earth was approximately 0.25 of an astronomical unit. These perturbations were computed by Mr. John D. Shea and Miss Muriel Wilkinson. They are based upon Merton's elements considered as osculating elements for 1922 July 1.0 Gr. M. T.

TABLE I

PERTURBATIONS IN EQUATORIAL RECTANGULAR CO-ORDINATES DUE TO THE ACTION OF THE EARTH

(In units of the seventh decimal place)

1922 Gr. M. T	ξ	η	ζ
May 17.0	+67.8	+18.7	−64.9
May 27.0	+40.2	+16.9	−42.7
June 6.0	+19.0	+12.2	−22.0
16.0	+05.8	+05.5	−07.3
June 26.0	+00.5	+00.7	−00.7
July 6.0	+00.4	+00.7	−00.6
16.0	+02.9	+05.8	−04.3
July 26.0	+06.2	+15.5	−10.0
Aug. 5.0	+09.7	+28.8	−16.5
Aug. 15.0	+12.5	+45.0	−23.1

To investigate the past history of this comet it was necessary to determine the perturbations due to the action of the Earth back to a point where they were of an order comparable with the perturbations due to the action of other planets, especially *Jupiter*, which were here neglected. This point was reached 1922 March 15.0 at which time the distance of the comet from the Earth was 0.8 of an astronomical unit.

Based upon our final elements these perturbations are:

TABLE II

PERTURBATIONS IN ECLIPTICAL RECTANGULAR CO-ORDINATES DUE TO THE ACTION OF THE EARTH

(In units of the seventh decimal place)

1922 Gr. M. T.	ξ	η	ζ
June 27.0	0	0	− 1
19.0	+ 4	+ 1	− 6
11.0	+ 12	+ 3	− 16
June 3.0	+ 25	+ 2	− 31
May 26.0	+ 43	− 2	− 48
18.0	+ 65	− 8	− 66
10.0	+ 91	−15	− 81
May 2.0	+122	−21	− 93
Apr. 24.0	+157	−27	−102
16.0	+199	−33	−106
Apr. 8.0	+247	−42	−106
Mar. 31.0	+301	−54	−100
23.0	+361	−71	− 90
Mar. 15.0	+425	−94	− 76

Using these perturbations and passing to the new Epoch (1922 March 15.0 Gr. M. T.) we have the following elements:

$$T = 1922\ \text{May}\ 15.22486\ \text{Gr. M. T.}$$

$$\left.\begin{array}{l} \omega = 355^\circ\ 03'\ 19''.9 \\ \Omega = 215\ \ 26\ \ 16.9 \\ i = 17\ \ 31\ \ 49.5 \end{array}\right\} 1922.0 \qquad \left.\begin{array}{rrr} 355^\circ & 03' & 40''.3 \\ 215 & 09 & 12.4 \\ 17 & 31 & 56.5 \end{array}\right\} 1902.0$$

$$\varphi = 44\ \ 10\ \ 07.1$$

$$\log a = 0.467075$$

$$\mu = 706''.958$$

$$P = 5.01894\ \text{years}$$

According to these elements the comet made a very close approach to *Jupiter* early in 1905, consequently the perturbations due to the action of *Jupiter* had to be taken into account. In the computation of the perturbations the comet reached a minimum distance from *Jupiter* of 0.08 of an astronomical unit on 1905, February 24.

Since the elements are derived from observations at only one apparition and therefore are not definitive, especially in the mean daily motion, it was considered that the uncertainties in the position of the comet, due to the elements, were of the order of the perturbations during the period from 1922 back to such a time when the comet was about two astronomical units from *Jupiter*. Therefore the elements were considered as osculating elements for 1906 July 2.0 Gr. M. T. The perturbations due to *Jupiter* were then carried backward, by the method of Variation of Constants, to 1902 July 23.0, which was the time of the appearance of Grigg's comet. The reference equinox and ecliptic are those of 1902.0. In TABLE III the column headed $\log \rho$ gives the logarithm of the comet's distance from *Jupiter*. In this table the perturbations are given in full in order to exhibit the manner in which they vary with the distance ρ and with changes in the elements themselves. These data will be valuable for comparative studies on this comet when future computations are based upon different osculating elements. It is to be noted that the intervals for the computation of the perturbations vary from forty days to one day. The one-day interval was carried from 1905 March 29 to January 30 during which time the approach to *Jupiter* passed through the minimum.

TABLE III

Perturbations Due to the Action of Jupiter

(Unity = 0°0001)

Gr. M. T.	Δi	$\Delta\Omega$	$\Delta\varphi$	$\Delta\pi$	$(\Delta L)_1$	$(\Delta L)_2$	$\Delta\mu$	$\log\rho$
1906								
June 12.0	+ 43	+ 98	+ 52	+ 20	+ 109.8	+ 1.2	− 0.12	0.31261
May 3.0	+ 156	+ 323	+ 185	+ 81	+ 376.4	+ 9.9	− 0.30	0.26942
Mar. 24.0	+ 313	+ 592	+ 367	+ 171	+ 714.1	+ 23.8	− 0.38	0.22461
Feb. 12.0	+ 529	+ 907	+ 617	+ 294	+ 1141.0	+ 38.1	− 0.32	0.17685
Jan. 3.0	+ 824	+ 1276	+ 962	+ 457	+ 1679.5	+ 46.7	− 0.08	0.12481
1905								
Nov. 24.0	+ 1227	+ 1705	+ 1442	+ 663	+ 2369.8	+ 41.5	+ 0.39	0.06662
Oct. 15.0	+ 1791	+ 2208	+ 2130	+ 923	+ 3278.9	+ 10.3	+ 1.23	9.99991
Sept. 5.0	+ 2601	+ 2803	+ 3150	+ 1249	+ 4527.6	− 64.9	+ 2.64	9.92106
July 27.0	+ 3823	+ 3524	+ 4761	+ 1665	+ 6365.5	− 214.9	+ 5.05	9.82430
17.0	+ 4231	+ 3728	+ 5325	+ 1785	+ 6986.7	− 269.2	+ 5.92	9.79622
July 7.0	+ 4691	+ 3944	+ 5968	+ 1913	+ 7684.3	− 333.4	+ 6.94	9.76621
June 27.0	+ 5217	+ 4174	+ 6720	+ 2050	+ 8491.6	− 408.6	+ 8.13	9.73384
17.0	+ 5824	+ 4419	+ 7608	+ 2197	+ 9431.1	− 496.8	+ 9.56	9.69896
June 7.0	+ 6524	+ 4679	+ 8669	+ 2351	+ 10554.8	− 600.7	+ 11.27	9.66090
May 28.0	+ 7349	+ 4957	+ 9963	+ 2516	+ 11898.0	− 723.6	+ 13.38	9.61916
18.0	+ 8320	+ 5254	+11561	+ 2688	+ 13573.4	− 870.0	+ 15.99	9.57304
May 8.0	+ 9480	+ 5571	+13589	+ 2861	+ 15688.0	− 1045.8	+ 19.30	9.52170
Apr. 28.0	+ 10868	+ 5907	+16222	+ 3030	+ 18464.6	− 1259.3	+ 23.60	9.46355
18.0	+ 12532	+ 6258	+19784	+ 3172	+ 22282.5	− 1522.7	+ 29.36	9.396804
14.0	+ 13277	+ 6399	+21571	+ 3213	+ 24232.5	− 1645.7	+ 32.24	9.367228
10.0	+ 14061	+ 6538	+23636	+ 3237	+ 26515.6	− 1781.1	+ 35.52	9.335677
6.0	+ 14872	+ 6672	+26041	+ 3240	+ 29219.1	− 1930.6	+ 39.32	9.301987
Apr. 2.0	+ 15679	+ 6797	+28867	+ 3207	+ 32464.9	− 2096.5	+ 43.73	9.265978
Mar. 29.0	+ 16432	+ 6904	+32220	+ 3127	+ 36410.0	− 2281.4	+ 48.87	9.227285
28.0	+ 16601	+ 6927	+33157	+ 3096	+ 37533.5	− 2331.0	+ 50.29	9.217212
27.0	+ 16758	+ 6948	+34136	+ 3061	+ 38715.6	− 2382.0	+ 51.77	9.206989
26.0	+ 16901	+ 6967	+35161	+ 3021	+ 39965.4	− 2434.5	+ 53.30	9.196498
25.0	+ 17028	+ 6983	+36238	+ 2975	+ 41285.4	− 2488.6	+ 54.91	9.185935
24.0	+ 17133	+ 6996	+37362	+ 2923	+ 42681.7	− 2544.4	+ 56.57	9.175136
23.0	+ 17214	+ 7006	+38544	+ 2863	+ 44161.7	− 2601.8	+ 58.30	9.164190
22.0	+ 17265	+ 7012	+39781	+ 2796	+ 45728.3	− 2661.0	+ 60.11	9.153074
21.0	+ 17281	+ 7014	+41080	+ 2720	+ 47391.4	− 2722.0	+ 61.98	9.141771
20.0	+ 17256	+ 7011	+42443	+ 2635	+ 49156.0	− 2785.0	+ 63.92	9.130274
19.0	+ 17182	+ 7003	+43872	+ 2539	+ 51031.1	− 2849.9	+ 65.95	9.118720
18.0	+ 17050	+ 6988	+45370	+ 2432	+ 53022.9	− 2916.9	+ 68.04	9.106924
17.0	+ 16852	+ 6967	+46943	+ 2312	+ 55142.5	− 2986.0	+ 70.21	9.095099
16.0	+ 16575	+ 6938	+48588	+ 2179	+ 57394.5	− 3057.3	+ 72.45	9.083125
15.0	+ 16206	+ 6900	+50311	+ 2030	+ 59792.7	− 3130.9	+ 74.76	9.071022
14.0	+ 15730	+ 6852	+52114	+ 1864	+ 62342.7	− 3206.9	+ 77.14	9.058896
13.0	+ 15131	+ 6792	+53994	+ 1681	+ 65055.1	− 3285.2	+ 79.57	9.046709
12.0	+ 14388	+ 6720	+55955	+ 1477	+ 67938.5	− 3366.0	+ 82.06	9.034507
11.0	+ 13481	+ 6632	+57993	+ 1251	+ 71001.4	− 3449.3	+ 84.58	9.022492
10.0	+ 12387	+ 6529	+60099	+ 1001	+ 74246.1	− 3535.2	+ 87.13	9.010504
9.0	+ 11075	+ 6406	+62279	+ 726	+ 77685.0	− 3623.5	+ 89.68	8.998658
8.0	+ 9522	+ 6263	+64514	+ 422	+ 81316.1	− 3714.6	+ 92.21	8.987137
7.0	+ 7698	+ 6096	+66794	+ 88	+ 85136.7	− 3808.0	+ 94.69	8.975856
6.0	+ 5567	+ 5902	+69111	− 279	+ 89149.7	− 3903.9	+ 97.10	8.965003
5.0	+ 3104	+ 5678	+71437	− 681	+ 93337.6	− 4002.2	+ 99.39	8.954791
4.0	+ 286	+ 5422	+73748	− 1121	+ 97688.3	− 4102.6	+101.51	8.945054
3.0	− 2930	+ 5127	+76029	− 1599	+102186.9	− 4205.1	+103.44	8.936100
2.0	− 6541	+ 4793	+78232	− 2119	+106791.8	− 4309.4	+105.10	8.928153
Mar. 1.0	− 10557	+ 4414	+80330	− 2683	+111477.4	− 4415.2	+106.46	8.920969
Feb. 28.0	− 15005	+ 3986	+82296	− 3288	+116201.6	− 4522.2	+107.48	8.915000
27.0	− 19835	+ 3507	+84074	− 3938	+120910.3	− 4630.1	+108.09	8.910225
26.0	− 25034	+ 2972	+85642	− 4631	+125559.9	− 4738.3	+108.28	8.906694
25.0	− 30563	+ 2377	+86969	− 5364	+130094.9	− 4846.5	+108.02	8.904440
24.0	− 36368	+ 1721	+88025	− 6137	+134464.6	− 4954.2	+107.30	8.903702
23.0	− 42362	+ 1003	+88794	− 6944	+138621.0	− 5060.9	+106.11	8.904279
Feb. 22.0	− 48507	+ 218	+89270	− 7779	+142523.2	− 5166.2	+104.47	8.906278

TABLE III—Continued.

Gr. M. T.	Δi	$\Delta\Omega$	$\Delta\varphi$	$\Delta\pi$	$(\Delta L)_1$	$(\Delta L)_2$	$\Delta\mu$	$\log\rho$
1905								
Feb. 21.0	− 54687	− 630	+89448	− 8639	+146140.8	− 5269.7	+102.40	8.909546
20.0	− 60859	− 1544	+89340	− 9513	+149442.4	− 5370.9	+ 99.96	8.914222
19.0	− 66921	− 2519	+88964	−10398	+152429.5	− 5469.5	+ 97.17	8.920019
18.0	− 72837	− 3557	+88341	−11284	+155078.5	− 5565.2	+ 94.11	8.926964
17.0	− 78537	− 4651	+87503	−12165	+157416.1	− 5657.6	+ 90.81	8.934828
16.0	− 84000	− 5801	+86471	−13032	+159430.2	− 5746.7	+ 87.33	8.943637
15.0	− 89167	− 6999	+85287	−13882	+161162.0	− 5832.3	+ 83.73	8.953182
14.0	− 94050	− 8243	+83974	−14709	+162613.9	− 5914.2	+ 80.04	8.963359
13.0	− 98622	− 9528	+82563	−15508	+163819.0	− 5992.3	+ 76.33	8.974084
12.0	−102886	−10847	+81079	−16278	+164801.4	− 6066.8	+ 72.61	8.985233
11.0	−106855	−12195	+79547	−17014	+165582.8	− 6137.6	+ 68.93	8.996764
10.0	−110528	−13568	+77987	−17717	+166193.2	− 6204.7	+ 65.29	9.008520
9.0	−113928	−14960	+76413	−18384	+166640.8	− 6268.2	+ 61.73	9.020455
8.0	−117065	−16366	+74843	−19018	+166965.2	− 6328.2	+ 58.26	9.032533
7.0	−119957	−17780	+73285	−19616	+167170.1	− 6384.7	+ 54.89	9.044666
6.0	−122624	−19201	+71750	−20181	+167275.9	− 6438.0	+ 51.62	9.056826
5.0	−125079	−20621	+70245	−20714	+167305.1	− 6488.0	+ 48.47	9.068952
4.0	−127342	−22037	+68774	−21215	+167255.8	− 6535.0	+ 45.43	9.081016
3.0	−129427	−23447	+67342	−21687	+167156.7	− 6578.9	+ 42.51	9.093002
2.0	−131350	−24847	+65952	−22130	+167003.0	− 6620.0	+ 39.70	9.104887
Feb. 1.0	−133124	−26233	+64604	−22547	+166813.2	− 6658.4	+ 37.00	9.116636
Jan. 31.0	−134762	−27604	+63300	−22938	+166586.8	− 6694.1	+ 34.42	9.128251
30.0	−136277	−28956	+62041	−23306	+166337.2	− 6727.2	+ 31.93	9.139713
28.0	−138978	−31599	+59654	−23975	+165776.1	− 6786.4	+ 27.28	9.162164
26.0	−141300	−34148	+57436	−24567	+165165.2	− 6836.6	+ 22.99	9.183920
24.0	−143309	−36595	+55379	−25087	+164515.2	− 6878.6	+ 19.07	9.204984
22.0	−145051	−38993	+53473	−25551	+163869.1	− 6913.0	+ 15.44	9.225355
20.0	−146574	−41159	+51705	−25960	+163211.4	− 6940.6	+ 12.11	9.245014
18.0	−147910	−43275	+50064	−26326	+162573.7	− 6961.7	+ 9.03	9.264029
16.0	−149085	−45276	+48541	−26651	+161944.2	− 6976.8	+ 6.19	9.282364
14.0	−150129	−47169	+47122	−26942	+161337.5	− 6986.5	+ 3.55	9.300082
12.0	−151054	−48956	+45802	−27202	+160749.9	− 6991.2	+ 1.10	9.317218
8.0	−152619	−52221	+43422	−27641	+159632.0	− 6986.6	− 3.29	9.349817
4.0	−153888	−55107	+41335	−28000	+158622.6	− 6965.6	− 7.14	9.380389
Jan. 0.0	−154930	−57657	+39494	−28294	+157691.8	− 6930.1	− 10.52	9.409082
1904								
Dec. 27.0	−155797	−59899	+37860	−28533	+156841.1	− 6881.9	− 13.52	9.436125
23.0	−156524	−61873	+36403	−28732	+156070.1	− 6822.4	− 16.19	9.461659
19.0	−157143	−63615	+35094	−28896	+155357.0	− 6752.8	− 18.59	9.485814
15.0	−157672	−65149	+33914	−29032	+154711.7	− 6674.0	− 20.76	9.508763
11.0	−158129	−66499	+32845	−29145	+154115.7	− 6587.0	− 22.72	9.530568
7.0	−158527	−67695	+31870	−29238	+153569.5	− 6492.5	− 24.51	9.551366
Dec. 3.0	−158875	−68750	+30981	−29316	+153066.3	− 6391.1	− 26.15	9.571205
Nov. 29.0	−159182	−69683	+30164	−29380	+152601.8	− 6283.5	− 27.65	9.590191
25.0	−159454	−70511	+29413	−29432	+152172.2	− 6170.0	− 29.04	9.608393
21.0	−159697	−71244	+28718	−29475	+151774.1	− 6051.3	− 30.32	9.625849
17.0	−159915	−71895	+28075	−29509	+151404.6	− 5927.6	− 31.52	9.642634
13.0	−160110	−72474	+27477	−29536	+151060.4	− 5799.3	− 32.63	9.658781
9.0	−160287	−72988	+26921	−29557	+150740.0	− 5666.7	− 33.66	9.674342
5.0	−160448	−73445	+26401	−29573	+150440.5	− 5530.1	− 34.63	9.689353
Nov. 1.0	−160594	−73852	+25914	−29584	+150160.5	− 5389.7	− 35.54	9.703860
Oct. 28.0	−160727	−74215	+25458	−29590	+149898.1	− 5245.8	− 36.40	9.717890
24.0	−160849	−74537	+25029	−29593	+149651.8	− 5098.6	− 37.20	9.731462
20.0	−160961	−74825	+24625	−29593	+149420.4	− 4948.2	− 37.97	9.744612
16.0	−161064	−75080	+24244	−29590	+149202.6	− 4794.9	− 38.69	9.757373
12.0	−161160	−75307	+23884	−29585	+148997.2	− 4638.8	− 39.37	9.769744
8.0	−161248	−75509	+23543	−29578	+148803.6	− 4480.0	− 40.02	9.781765
Oct. 4.0	−161330	−75688	+23220	−29568	+148620.5	− 4318.7	− 40.63	9.793450
Sept. 30.0	−161406	−75846	+22913	−29557	+148447.3	− 4155.0	− 41.22	9.804814
20.0	−161575	−76165	+22210	−29523	+148054.2	− 3735.9	− 42.57	9.83194
Sept. 10.0	−161719	−76395	+21586	−29482	+147706.9	− 3304.1	− 43.78	9.85739
Aug. 31.0	−161841	−76555	+21028	−29436	+147400.9	− 2860.8	− 44.87	9.88134
Aug. 21.0	−161948	−76660	+20526	−29385	+147128.2	− 2407.1	− 45.85	9.90391

TABLE III—Continued

Gr. M. T.	Δi	$\Delta\Omega$	$\Delta\varphi$	$\Delta\pi$	$(\Delta L)_1$	$(\Delta L)_2$	$\Delta\mu$	$\log\rho$
1904								
Aug. 11.0	−162040	−76722	+20072	−29332	+146886.3	− 1944.1	− 46.75	9.92534
Aug. 1.0	−162122	−76748	+19660	−29276	+146666.1	− 1472.4	− 47.57	9.94564
July 22.0	−162194	−76748	+19283	−29220	+146471.8	− 992.8	− 48.33	9.96494
12.0	−162257	−76726	+18938	−29161	+146293.2	− 506.0	− 49.03	9.98335
July 2.0	−162315	−76686	+18621	−29102	+146132.6	− 12.4	− 49.68	0.00092
June 22.0	−162366	−76632	+18327	−29042	+145986.0	+ 487.5	− 50.29	0.01774
12.0	−162412	−76567	+18056	−28982	+145851.9	+ 993.3	− 50.86	0.03378
June 2.0	−162454	−76493	+17804	−28922	+145729.9	+ 1504.6	− 51.39	0.04924
May 23.0	−162492	−76412	+17569	−28862	+145617.4	+ 2021.0	− 51.89	0.06401
May 13.0	−162527	−76325	+17350	−28802	+145514.4	+ 2542.2	− 52.36	0.07820
Apr. 23.0	−162588	−76139	+16953	−28683	+145331.5	+ 3598.2	− 53.23	0.10502
Apr. 3.0	−162640	−75942	+16603	−28565	+145176.7	+ 4670.7	− 54.01	0.12992
Mar. 14.0	−162685	−75739	+16291	−28449	+145041.7	+ 5758.0	− 54.72	0.15305
Feb. 23.0	−162723	−75535	+16013	−28335	+144927.2	+ 6859.0	− 55.37	0.17467
Feb. 3.0	−162756	−75330	+15763	−28222	+144827.2	+ 7972.3	− 55.96	0.19482
Jan. 14.0	−162786	−75127	+15537	−28112	+144740.7	+ 9097.2	− 56.52	0.21371
1903								
Dec. 25.0	−162811	−74927	+15333	−28004	+144666.1	+10232.8	− 57.03	0.23143
Dec. 5.0	−162834	−74731	+15146	−27897	+144601.3	+11378.3	− 57.52	0.24798
Nov. 15.0	−162855	−74538	+14976	−27793	+144545.5	+12533.2	− 57.97	0.26355
Oct. 26.0	−162873	−74350	+14820	−27691	+144497.6	+13697.0	− 58.40	0.27818
Oct. 6.0	−162889	−74166	+14677	−27591	+144456.8	+14869.1	− 58.81	0.29189
Sept. 16.0	−162904	−73987	+14545	−27492	+144422.7	+16049.2	− 59.20	0.30475
Aug. 27.0	−162917	−73812	+14423	−27396	+144394.4	+17236.8	− 59.56	0.31681
July 18.0	−162941	−73474	+14205	−27208	+144355.1	+19633.5	− 60.26	0.33876
June 8.0	−162960	−73155	+14020	−27027	+144333.7	+22056.7	− 60.89	0.35803
Apr. 29.0	−162976	−72850	+13859	−26853	+144330.4	+24504.4	− 61.49	0.37487
Mar. 20.0	−162989	−72560	+13720	−26685	+144343.3	+26975.0	− 62.04	0.38962
Feb. 8.0	−163000	−72285	+13600	−26525	+144371.2	+29466.7	− 62.54	0.40258
1902								
Dec. 30.0	−163010	−72023	+13496	−26373	+144413.6	+31978.0	− 63.01	0.41417
Nov. 20.0	−163017	−71777	+13408	−26231	+144468.7	+34506.9	− 63.43	0.42496
Oct. 11.0	−163024	−71547	+13334	−26102	+144534.9	+37051.5	− 63.79	0.43569
Sept. 1.0	−163028	−71339	+13272	−25987	+144609.0	+39609.1	− 64.07	0.44750
July 23.0	−163032	−71156	+13223	−25893	+144686.0	+42176.0	− 64.26	

For the sake of comparison the elements of this comet carried back to 1902 July 23.0, the elements of Grigg's comet computed by Crommellin (*The Observatory*, August 1922) with an assumed period and the ω, Ω, and i of the parabolic elements by Grigg, together with the heliocentric position for 1902 July 23.0 Gr. M. T. computed from the two sets of elliptic elements are given:

Comet Epoch	*b* 1922 (Skjellerup) 1902 July 23.0 Gr. M. T.		*c* 1902 (Grigg) 1902 July 23.0 Gr. M. T.		*c* 1902 (Grigg) (Parabolic)	
M	40°243		3°881			
ω	359.588	1902.0	348.640	1902.0	301°77	1902.0
Ω	208.038		223.450		217.52	
i	1.229		8.593		16.72	
φ	45.491		48.127			
$\log a$	0.47671		0.46660			
Period (years)	5.1887		5.0107			
$\pi+v$	336°1		249°4			
$\log r$	0.4226		9.9135			

The difference between the heliocentric positions of the two comets would seem to lead to the conclusion that they are not identical. But the difference in heliocentric longitude, 86°7, could be accounted for by an average error of 18″ in the mean motion due partly to uncertainty in its initial value and partly to the cumulative effect of the latter upon its perturbations.

That there may be some appreciable uncertainty in our starting mean motion (707″) is evidenced from the following table of elements:

TABLE IV

Elements for Comet *b* 1922 (Skjellerup)

Date of Perihelion	ω	Ω	*i*	φ	log *a*	μ	Period in years	Interval of arc	Computer	Reference
May 14.28	353°.7	216°.7	16°.9	39°.5	0.3888	926″	3.83	8 days	Crawford and Meyer	*L. O. B.* 340
" 15.51	355.5	215.0	17.7	45.7	0.4949	642	5.53	21 "	Crawford and Meyer	*L. O. B.* 341
" 15.17	355.0	215.5	17.5	43.9	0.4622	719	4.93	27 "	Ebell	*A. N.* 5166
" 15.29	355.2	215.3	17.6	44.5	0.4736	691	5.13	33 "	Merton	*A. N.* 5166
" 15.22	355.1	215.4	17.5	44.2	0.4671	707	5.02	86 "	Crawford and Meyer	

It is of interest to note the variation in the value of μ, especially for our second orbit based on an arc of 21 days. With the aid of our final elements and perturbations due to the Earth, Dr. H. Thiele derived the following residuals for the observations used in our second orbit:

	$\Delta\alpha$	$\Delta\delta$
May 21.6+	$+0^{s}.10$	$+0''.2$
May 29.6+	-0.63	$+8.4$
June 11.6+	$+1.57$	-2.8

The residuals for the observations of May 29 and June 11 account for the difference in our μ for this orbit as compared with the other orbits.

Van Biesbroeck reports (*A. J.* 809) that on June 11 the comet was very diffuse and the rising Moon made the settings difficult.

Conclusions: As a result of this investigation it can not be stated definitely at this time whether or not the two comets are identical. A slight change in the mean motion adopted would produce considerable differences in the perturbations at the critical time of the very close approach to *Jupiter*, which might easily account for the difference in heliocentric position on 1902 July 23.0, and also for the differences in *i*, Ω, and π which exist between the elements of the two comets just given. During the computation of the perturbations μ ranged from 684″ to 746″, and *i* ranged from 19° 16′ to 1° 14′.

Before a definite conclusion on the question of identity can be reached it will be necessary to have a better set of osculating elements (especially μ) based upon observations of the 1922 and 1927 apparitions, and then to recompute the perturbations due to the action of *Jupiter* from 1922 back to 1902. Such a reduction may possibly show a still closer approach to *Jupiter* in 1905 and yield another interesting case similar to that of Comet *d* 1889 (Brooks).

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Berkeley Astronomical Department
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THIRD CATALOGUE OF SPECTROSCOPIC BINARY STARS

It is now a little more than fourteen years since the Second Catalogue of Spectroscopic Binary Stars[1] was issued by Professor Campbell. In this interval the number of known spectroscopic binaries has increased from 306 to 1054, while in the same period the number of well-determined orbits has increased from 71 to 248. There is thus an urgent need that the data now available be collected in convenient form for the use of observers and for students especially interested in the various problems whose solution is dependent upon a knowlege of the radial velocities and orbital elements of these stars. To meet this demand the Third Catalogue has been prepared with the aim of listing all stars whose variable radial velocities had been announced prior to July 1, 1924, and of including the principal facts concerning these systems available to me on that date.

The assumption that the variable radial velocity of a star is evidence of its orbital motion in a binary system appears in general to be justified. However, as a result of the more intimate study of the phenomena exhibited by certain classes of stars listed as spectroscopic binaries, evidence has been accumulating within recent years that we may not be justified in so interpreting all cases of variable radial motion. Thus, grave difficulties have been encountered in the interpretation of Cepheid variables as binary systems and the hypothesis has been advanced and ably supported that the observed variable velocity is due to pulsations of a single star. In the present state of our knowledge it appears the part of wisdom to continue the policy of including these stars in a list of spectroscopic binaries, although in statistical studies they should be excluded or at least treated separately.

In the preparation of the present catalogue, an effort has been made to arrange the data in a form convenient for the different classes of investigators who may wish to use it. To this end certain changes in the form adopted in the two previous catalogues have been introduced, which effect at the same time a considerable saving in the cost of publication. The material has been arranged in three tables, the contents of which are briefly described in the following paragraphs.

Table I lists all stars for which a variation in radial velocity appears to have been established. In Table II are included certain stars which have been announced as spectroscopic binaries but whose variable velocity has later been disproved or at least has been found to depend upon insufficient or doubtful evidence. To this class belong stars of very poor spectra, for which the reality of the observed variable velocity is still open to question. In this table are also listed certain stars of the later spectral classes, for which an observed range in velocity of scarcely more than 5 km/sec. has been announced by the Lick observers, but which has later been reduced to only 2 or 3 km/sec. by the application of systematic corrections derived from a discussion of the results for the entire radial velocity program. Many, if not all, of these stars are still regarded as probable binaries, but at present they do not belong in a list of those whose radial velocities have definitely been shown to be variable. A few stars are also noted in Table II which have been announced as probable binaries, either from suspected variation in velocity or from changes in the character of the spectral lines. No attempt has been made to record all suspected cases of variability since such a list would include much material of doubtful value. Obviously the line of division between Tables I and II, or between definitely determined and probable variable velocity, is in practice by no means a sharp one, and depends largely upon the judgment of the individual observer. Undoubtedly a few of the stars of Table I will be shown by later and more accurate observations to belong in the doubtful class of Table II.

The numbers in the first column of the tables are the serial numbers assigned to these stars in Boss's *Preliminary General Catalogue.* In the second column the usual designation of the star is quoted. The names of the constellations are written in the three letter abbreviations proposed by Hertzprung and Russell and adopted by the International Astronomical Union.[2] For those stars having neither a Boss number nor a constellation designation the numbers quoted are, in general, those of the *Henry Draper Catalogue.* Columns three and four contain the Boss right ascension and declination of the star for 1900.0. The visual magnitude and spectral types given respectively in the fifth and sixth column are taken from the *Henry Draper Catalogue.* The final column contains the name of the observer by whom the variable radial velocity was detected and the reference to the published announcement. If the spectrograms were secured and measured by several different observers with no statement as to which one made the discovery, credit for it has been in general given to the observatory from which the announcement was made. A few notes have also been added, indicating the range in the observed radial velocity as well as the quality of the spectral lines (good, fair, or poor) where these data have been given by the discoverer. In certain cases the observer has assigned a spectral type differing from that given in the Harvard classification, and this has been noted in the final column.

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[1] *L. O. B.*, **6**, 17, 1910.

Table III contains the orbital elements for 248 spectroscopic binaries or all for which we have well determined or approximate orbits. Where two or more orbits have been published, only the best or most recent elements have been quoted. Certain exceptions to this rule, however, have seemed justified, especially in those cases where real changes in the elements appear to be indicated. Columns seven to fourteen, inclusive, list the orbital elements as derived from the radial velocity curve of a spectroscopic binary, while the remaining columns give the computer and reference to the published elements.

The elements of the orbit are defined as follows:

P = apparent period of revolution in mean solar days, unless specified in mean solar years. The true period of revolution, P_o, may be found from the apparent period by means of the equation

$$P_o = P/(1+\frac{V_o}{300{,}000}).$$

T = Greenwich mean time of periastron passage, expressed in Julian Days; except (1) that for variable star orbits the quantity in the column T is the mean solar interval after maximum or minimum brightness, as specified in each case; and (2) that for circular orbits T has been given significance by the computers, as described in the column "Remarks."

ω = angular distance of periastron from the ascending node, measured in the direction of orbital motion. (At the ascending node the radial velocity of the observed body has its maximum value. Spectrographic observations enable the computer to distinguish between the ascending and descending nodes; but micrometer observations of visual double stars do not distinguish between the two nodes, and they also leave the value of ω uncertain by 180°.)

e = eccentricity of the orbit.

K_1 = semi-amplitude of velocity curve of the primary member of the system, with reference to the center of mass of the system.

K_2 = semi-amplitude of velocity curve of the secondary member of the system, with reference to the center of mass of the system.

K_1+K_2 = semi-amplitude of the velocity curve of one member of the system, with reference to the other member of the system.

a_1 = semi major-axis of the orbit of the primary member of the system, with reference to the center of mass of the system.

a_2 = semi major-axis of the orbit of the secondary member of the system, with reference to the center of mass of the system.

a_1+a_2 = semi major-axis of the orbit of one member of the system, with reference to the other member of the system.

i = inclination of the orbit plane, conveniently defined as the angle between the line of sight and the normal to the orbit plane. (Spectrographic observations leave the value of i undetermined; micrometer observations of a visual binary system leave the quadrant of i undetermined; spectrographic and micrometer observations combined determine i completely, but the number of known systems available for both classes of observation is at present very limited.)

m_1 = mass of primary member of system.

m_2 = mass of secondary member of system.

m_1+m_2 = mass of system.

$\odot$ = mass of Sun.

V_o = radial velocity of the center of mass of the system.

r_1 = radius of primary member.

r_2 = radius of secondary member.

r_s = radius of Sun.

d_1 = mean density of primary member.

d_2 = mean density of secondary member.

D_o = mean density of Sun.

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[2] *Observatory,* **45**, 400, 1922.

Data for the dimensions and masses of the system are furnished by the following equations:

I. One stellar spectrum observed, with comparison spectra:

$$a_1 \sin i = [4.13833]\ (1-e^2)^{\frac{1}{2}}\ K_1 P, \tag{1}$$

$$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2} = [3.01642-10]\ (1-e^2)^{\frac{3}{2}}\ K_1^3 P \odot. \tag{2}$$

II. Two stellar spectra observed, either without comparison spectra, as by means of objective-prism spectrographs, or with comparison spectra:

$$(a_1+a_2) \sin i = [4.13833]\ (1-e^2)^{\frac{1}{2}}\ (K_1+K_2)\ P, \tag{3}$$

$$(m_1+m_2) \sin^3 i = [3.01642-10]\ (1-e^2)^{\frac{3}{2}}\ (K_1+K_2)^3\ P \odot. \tag{4}$$

III. Two stellar spectra observed, with comparison spectra:

$$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2} = [3.01642-10]\ (1-e^2)^{\frac{3}{2}}\ K_1^3\ P \odot, \tag{5}$$

$$m_1 \sin^3 i = [3.01642-10]\ (1-e^2)^{\frac{3}{2}}\ (K_1+K_2)^2\ K_2 P \odot, \tag{6}$$

$$m_2 \sin^3 i = [3.01642-10]\ (1-e^2)^{\frac{3}{2}}\ (K_1+K_2)^2\ K_1 P \odot, \tag{7}$$

$$\frac{m_1}{m_2} = \frac{K_2}{K_1} \tag{8}$$

Through the kindness of Professors Adams, Belopolsky, Curtiss, Frost, Harper, Jones, Lunt, Plaskett, and Stewart unpublished numerical data were placed at the author's disposal for which he desires to express his appreciation. He is also under obligation to Professor Russell, and especially to his colleagues, Professors Campbell and Aitken, for many valued suggestions concerning the form and arrangement of the present catalogue.

July 1, 1924. J. H. Moore.

ABBREVIATIONS

The following abbreviations have been used in the references to publications:

ApJ	Astrophysical Journal
AN	Astronomische Nachrichten
AO	Publications of the Allegheny Observatory
ASP	Publications of the Astronomical Society of the Pacific
CA	Annals of the Cape Observatory
CR	Comptes Rendus Paris Academy
DAO	Publications of the Dominion Astrophysical Observatory, Victoria.
DetO	Publications of the Astronomical Observatory of the University of Michigan, Detroit.
DO	Publications of the Dominion Observatory, Ottawa.
HCO	Annals of Harvard College Observatory
LOB	Lick Observatory Bulletin
LowOB	Bulletins of the Lowell Observatory
PA	Popular Astronomy
RASC	Publications of the Royal Astronomical Society of Canada.
Sci	Science.

TABLE I

Boss	Star	R.A. 1900	Decl.	Mag.	Class	Discoverer and Reference
1	33 Psc	$0^h\ 0^m.2$	− 6° 16′	4.68	K0	Miss Hobe, *LOB* **6**, 140, 1911. Range 33 km.
9	5 Cet	3.1	− 3 0	6.32	K0	Adams, *ASP* **26**, 261, 1914. Range 31 km.
10	α And	3.2	28 32	2.15	A0p	Slipher, *Low OB* **1**, 57, 1904. Two spectra suspected. Orbit.
12	β Cas	3.8	58 36	2.42	F5	Mellor, *Det O* **3**, 77, 1917. Range 11 km. Per. 27 d.
……..	SX Cas	5.5	54 20	var	……..	Adams, Joy, *ASP* **31**, 308, 1919. Range 75 km. Algol variable. Spectrum A2.
27	γ Peg	8.1	14 38	2.87	B2	Burns, *LOB* **6**, 141, 1911. Range 13 km.
46	……………………	12.4	50 53	6.12	B0	Adams, *RASC* **10**, 426, 1916. Two spectra. Orbit.
50	σ And	13.1	36 14	4.51	A2	Yerkes, *ApJ* **32**, 300, 1910. Two spectra.
……..	TV Cas	13.9	58 35	var	B9	Plaskett, *DAO* **2**, 141, 1922. Algol var. Two spectra. Orbit.
……..	SW And	18.5	28 51	var	F1	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 51 km.
67	……………………	18.9	51 28	5.36	B3	Mt. Wilson, *ApJ* **35**, 172, 1912. Range 40 km. fr.
76	……………………	20.7	79 30	6.53	B9	Plaskett, *DAO* **1**, 287, 1921. Range 62 km. brd.
……..	TU Cas	20.9	50 43	var	var	Adams, Joy, *ASP* **31**, 40, 1919. Range 39 km. Cepheid var. F0–F9. Per = $2^d.137$.
78	α Phe	21.3	−42 51	2.44	K0	Wright, *LOB* **3**, 110, 1905. Orbit.
82	……………………	22.8	43 50	5.16	A2	Baker, *AO* **2**, 191, 1912. Orbit.
……..	DM 61°.92	23.2	61 57	8.6	B	*DAO*, 1924. Range 44 km.
91	49 Cet	25.4	−24 20	5.23	A3	Mt. Wilson, *ApJ* **35**, 172, 1912. fr.
99	λ Phe	26.6	−49 21	4.88	A2	Chile Sta. *ASP* **34**, 168, 1922. Range 54.
103	κ Cas	27.3	62 23	4.24	B0	Merrill, *LOB* **6**, 141, 1911. Range 23.
108	16 Cas	28.6	66 12	6.42	B9	Plaskett, *RASC* **13**, 60, 1919. Range 28. brd.
116	13 Cet	30.1	− 4 9	5.24	G0	Frost, *ApJ* **25**, 60, 1906. Brighter comp. visual double. Orbit.
123	π And	31.5	33 10	4.44	B3	Frost, Adams, *ApJ* **18**, 384, 1903. Orbit.
132	δ And	34.0	30 19	3.49	K2	Lick, *LOB* **7**, 102, 1912. Range 7.
141	ξ Cas	36.5	49 58	4.85	B3	Frost, Adams, *ApJ* **18**, 384, 1903.
145	π Cas	37.9	46 29	5.02	A5	Frost, *PA* **22**, 12, 1914. Two spectra. Orbit.
146	ρ Tuc	38.2	−66 1	5.46	F5	Chile Sta. *LOB* **8**, 71, 1914. Orbit.

TABLE I—Continued.

Boss	Star	R.A., 1900		Decl.	Mag.	Class	Discoverer and Reference
149	....	0^h	38^m9	47° 19′	5.55	B3	Frost, Lee, *ApJ* **30**, 62, 1909. Two spectra suspected.
150	21 Cas		39.0	74 26	5.59	A2	Hnatek, *AN* **210**, 245, 1919. Range 15 km. (3 plates).
159	23 Cas		41.1	74 18	5.39	B8	Mt. Wilson, *ApJ* **35**, 172, 1912. Two spectra suspected. Orbit.
164	ζ And		42.0	23 43	4.30	K0	Miss Hobe, *LOB* **6**, 141, 1911. Orbit.
174	64 Psc		43.7	16 24	5.23	F5	Lick, *ASP* **30**, 351, 1918. Two spectra. Rel. vel. 90 km. fr.
175	ν And		44.3	40 32	4.42	B3	Curtis, *LOB* **2**, 29, 1903. Two spectra. Orbit.
179	....		44.7	63 42	5.45	F2	Young, *DAO* **1**, 287, 1921. Range 18 km. gd.
201	....		50.8	59 49	5.54	B9	Frost, Lee, *Sci* **32**, 876, 1910.
							Young, *DAO* **1**, 287, 1921. Range 48 km. Character of lines varies.
206	η And		51.9	22 53	4.62	G5	Campbell, *ApJ* **12**, 256, 1900. Two spectra.
....	U Cep		53.4	81 20	var	A0	Slipher, *ApJ* **25**, 284, 1907. Range 95 km. Algol var. Per. $2^d492884$ with small variations; Spect. ftr. comp. K0.
216p	Σ 79		54.4	44 10	6.84	B9	Plaskett, *DAO* **1**, 287, 1921. Range 47 km. pr.
216f	Σ 79		54.4	44 10	6.04	B9	Plaskett, *DAO* **1**, 287, 1921. Range 41 km. pr.
224	σ Psc		57.3	31 16	5.46	B9	Lick, *ASP* **30**, 352, 1918. Two spectra. gd.
234	....		59.8	14 24	5.65	F2	H. Plaskett, *DAO* **1**, 287, 1921. Range 11 km. gd.
....	Grm 234	1	0.0	62 14	6.44	A3	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 76 km. Two spectra suspected. A1.
260	ζ Phe		4.2	−55 47	4.13	B8	Chile Sta. *LOB* **8**, 80, 1914. Range 207 km. pr.
271	τ Psc		6.2	29 34	4.70	K0	Lick, *ASP* **34**, 168, 1922. Range 6 km.
281	φ Psc		8.3	24 3	4.64	K0	Miss Hobe, *LOB* **6**, 141, 1911. Range 15 km.
282	ζ Psc btr.		8.5	7 3	5.57	A5	Plaskett, *RASC* **13**, 193, 1919. Range 46 km. pr.
283	ζ Psc ftr.		8.5	7 3	6.49	F8	Plaskett, *RASC* **13**, 193, 1919. Range 54 km. gd.
295	89 Psc		12.6	3 5	5.28	A2	Lee, *ApJ* **39**, 39, 1914. Two spectra suspected. Range 39 km.
298	φ Cas		13.8	57 42	5.25	F7p	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 10 km. Enhanced lines strong and displaced to red with respect to arc lines.
300	υ Psc		14.0	26 44	4.67	A2	Albrecht, *LOB* **5**, 174, 1910. Range 23 km.
307	47 And		17.9	37 12	5.53	A0	Young, *RASC* **13**, 60, 1919. Two spectra. Rel. vel. 112 km. A5.
....	HR 407		20.1	23 0	6.07	F5	Plaskett, *RASC* **13**, 193, 1919. Range 23 km. gd.
325	α U. Mi.		22.6	88 46	2.12	F8	Campbell, *ApJ* **10**, 180, 1899. Triple sys. Orbit.
....	Lal 2682		23.5	21 12	7.8	K1	Adams, *ASP* **27**, 132, 1915. Range 64 km.
327	....		23.8	69 45	5.95	F5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 31 km. F4.
329	γ Phe		24.0	−43 50	3.40	K5	Palmer, *LOB* **3**, 110, 1905. Orbit.
....	RR Cet		27.0	0 50	var	A0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 85 km. Per = $0^d553022$. Fo.
369	τ And		34.7	40 4	4.90	B8	Merrill, *LOB* **6**, 142, 1911. Two spectra. Rel. vel. 67 km.
371	42 Cas		35.2	70 7	5.26	A0	Hnatek, *AN* **210**, 245, 1919. Range 13 km. (2 plates).
373	Σ145 btr.		35.7	25 14	6.26	F5	Adams, Joy, *ASP* **31**, 40, 1919. Two spectra. Orbit.
380	....		36.6	60 3	5.75	B9	Plaskett, *DAO* **1**, 287, 1921. Range 47 km. pr.
384	φ Per		37.4	50 11	4.19	B0p	Campbell, *LOB* **1**, 158, 1902. Orbit.
403	4 Ari		42.8	16 27	5.73	A0	Young, *DAO* **1**, 287, 1921. Range 32 km. gd.
....	HR 526 S		43.3	47 24	5.99	A2	Christie, *RASC* **18**, 166, 1924. Two spectra. Rel. vel. 102 km.
412	1 Per		45.4	54 39	5.49	B3	Mt. Wilson, *ApJ* **35**, 172, 1912. Range 100 km. pr.
416	ζ Cet		46.5	−10 50	3.92	K0	Campbell, *LOB* **3**, 84, 1905.
421	α Tri		47.4	29 6	3.58	F5	Merrill, *LOB* **6**, 142, 1911. Orbit.
425	ω Cas		48.2	68 12	5.03	B8	Mt. Wilson, *ApJ* **35**, 173, 1912. Orbit.
426	ξ Psc		48.4	2 42	4.84	K0	Wright, *LOB* **1**, 22, 1901. Range 7 km.
428	β Ari		49.1	20 19	2.72	A5	Vogel, Eberhard, *AN* **163**, 145, 1903. Orbit.
433	φPhe		50.2	−43 0	5.00	B9	Moore, *LOB* **6**, 150, 1911. Range 13 km. gd.
435	Σ 186		50.7	1 21	6.18	G0	H. Plaskett, *DAO* **1**, 287, 1921. Range 15 km.
436	ι Ari		51.9	17 20	5.16	G5	Lick, *ASP* **34**, 168, 1922. Range 17 km.
443	Σ 185		52.9	75 1	6.64	A0	Harper, *DAO* **1**, 163, 1920. Range 83 km.
449	50 Cas		54.9	71 56	4.06	A2	Burns, *LOB* **6**, 142, 1911. 4481 usually double.
459	g Per		55.6	54 0	4.99	B8	Frost, Adams, *ApJ* **19**, 152, 1904. Range 60 km.
463	α′ Psc Σ202		56.9	2 17	5.23	A2p	Lee, *ApJ* **38**, 502, 1913.
463	α² Psc		56.9	2 17	4.33	A2p	Campbell, *LOB* **6**, 142, 1911. Range 25 km. Harvard finds composite spectrum.
476	κ Ari	2	1.0	22 10	5.08	A0	Lick, *ASP* **30**, 352, 1918. Two spectra. Rel. vel. 80 km. gd. Prelim. per. = 3^d08, V = +9 km., e = 0.24.

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
480	58 And	2^h 2^m5	37° 23′	4.77	A2	Plaskett, *RASC* **13**, 60, 1919. Range 59 km. fr.
482	β Tri	3.6	34 31	3.08	A5	Mitchell, *Sci* **28**, 853, 1908. Two spectra. Per = 37^d. *ApJ* **30**, 240, 1909.
497	ι Tri btr.	6.6	29 50	5.20	G0	Harper, *DAO* **1**, 163, 1920. Two spectra. Orbit.
497	ι Tri ftr.	6.6	29 50	6.4	A5	Harper, *DAO* **1**, 163, 1920. Two spectra. Orbit.
499	b And	6.9	43 46	5.08	K0	Lick, *ASP* **34**, 168, 1922. Range 12 km.
500	6 Per	7.0	50 36	5.40	K0	Lick, *ASP* **34**, 168, 1922. Range 12 km.
505	ξ¹ Cet	7.7	8 23	4.54	G5	Campbell, *LOB* **1**, 22, 1901.
....	BD+54°500	8.6	55 8	8.01	B9	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 67 km.
514	δ Tri	10.9	33 46	5.07	G0	Miss Hobe, *LOB* **6**, 142, 1911. Orbit.
522	c And	12.8	46 55	5.12	A0	Mt. Wilson, *ApJ* **35**, 173, 1912. Range 19 km. fr. Composite spectrum.
530	ο Cet	14.3	− 3 26	var	Md	Joy, *PA* **31**, 645, 1923. Vis. double. Orbit.
538	....	16.7	41 1	7.7	B	Young, *DAO* **1**, 287, 1921. Range 34 km. fr.
546	ξ Ari	19.5	10 9	5.53	B5	Mt. Wilson, *Sci* **37**, 643, 1913. Two spectra. Rel. vel. 260 km. Adams, Joy, Sanford, *ASP* **36**, 137, 1924. B8.
....	DM 58°467	19.5	58 25	8.04	Oe	*DAO*, 1924. Range 51 km.
550	ι Cas Σ262	20.8	66 57	4.59	A5p	Yerkes, *ApJ* **32**, 300, 1910. brtst. comp. vis. triple star.
560	ξ² Cet	22.8	8 1	4.34	A0	Lee *ApJ* **39**, 39, 1914. Range 20 km.
563	κ Eri	23.3	−48 9	4.44	B5	Moore, *LOB* **6**, 150, 1911. Range 12 km. gd.
580	ω For	29.5	−28 40	4.95	B9	Moore, Paddock, *LOB* **6**, 142, 1911. Range 10 km.
593	Σ 5 btr.	31.2	24 13	6.57	F5	Adams, Joy, *ApJ* **49**, 186, 1919. Orbit.
604	δ Cet	34.4	− 0 6	4.04	B2	Frost, Adams, *ApJ* **17**, 150, 1903. Range 10 km. Vel. curve var. Henroteau, *DO* **5**, 413, 1922.
606	33 Ari	34.8	26 38	5.38	A2	Plaskett, *RASC* **13**, 193, 1919. Range 35 km. fr.
	DM 56°693	35.5	56 28	8.4	Oe	*DAO*, 1924. Range 51 km.
610	12 Per	35.9	39 46	4.99	G0	Campbell, *ApJ* **12**, 254, 1900. Two spectra. App. orbit.
613	....	36.2	67 24	5.84	A2	Young, *DAO* **1**, 287, 1921. Range 90 km. gd.
618	ζ Hor	37.5	−54 59	5.26	F2	Chile Sta. *LOB* **7**, 96, 1912. Two spectra, Rel. vel. 135 km.
627	π Cet	39.4	−14 17	4.39	B5	Moore, Albrecht, *LOB* **5**, 174, 1910. Range 13 km.
	RZ Cas	39.9	69 13	var	A0	Hartmann, *AN* **173**, 102, 1906. Orbit. Frost, *ApJ* **25**, 59, 1907.
630	G For	40.1	−32 57	6.14	A0	Chile Sta. *LOB* **8**, 80, 1914. Range 74. Mg gd.
637	SU Cas	43.0	68.28	var	F5	Adams, *ApJ* **47**, 46, 1918. Cepheid var. Orbit.
641	π Ari	43.7	17 3	5.30	B5	Mt. Wilson, *ApJ* **35**, 173, 1912. Orbit.
653	τ Per	47.2	52 21	4.06	G0 A5	Wright, *LOB* **1**, 22, 1901. Composite spectrum.
....	HR 894	53.8	37 45	5.92	B9	Young, *RASC* **13**, 193, 1919. Range 28 km. fr.
680	θ¹ Eri	54.5	−40 42	3.42	A2	Wright, *LOB* **3**, 110, 1905. Two spectra.
694	γ Per	57.6	53 7	3.08	F5 A3	Moore, *LOB* **5**, 61, 1908. Range 7 km. Composite spectrum.
....	RX Cas	58.8	67 11	var	....	Adams, Joy, *ASP* **31**, 308, 1919. Range 11 km. Algol variable. Spectrum G8, except Hβ, Hγ and Hδ are bright.
708	β Per	3 1.7	40 34	var	B8	Vogel, *AN* **123**, 289, 1889. Algol var. Prototype. Orbit.
713	κ Per	2.7	44 29	4.00	K0	Campbell, Albrecht, *LOB* **5**, 174, 1910. Range 5 km.
726	....	8.6	84 34	5.78	K0	Harper, *DAO* **1**, 287, 1921. Range 11 km.
731	....	9.2	30 11	5.53	A0	Mt. Wilson, *ApJ* **35**, 173, 1912. Range 19 km. gd. Composite spectrum suspected.
735	....	10.5	69 22	6.68	A0	H. Plaskett, *DAO* **1**, 287, 1921. Range 40 km. brd. H, gd. K, 4481, 4534.
739	ζ Eri	11.0	− 9 11	4.90	A3	Wilson, *LOB* **6**, 143, 1911. Range 27 km.
741	....	11.2	65 17	4.76	B3p	Curtiss, *Det O* **2**, 39, 1915. Range 45 km. between 1912 and 1916 series. Per. 2^y3±. K line constant. Vel −9 km. Hnatek, *AN* **210**, 246, 1919. Suspects.
757	l Per	14.8	42 58	4.98	A2	Lee, *ApJ* **60**, 1924. Range 56 km. fr. 4481.
778	ο Tau	19.4	8 41	3.80	G5	Moore, *LOB* **4**, 161, 1907. Range 8 km.
784	ξ Tau	21.7	9 23	3.75	B8	Campbell, *LOB* **5**, 62, 1908. Range 98 km.
786	....	21.9	58 32	4.76	A0p	Young, *LOB* **6**, 143, 1911. Range 10 km. gd.
787	....	22.0	33 28	5.60	A0	Young, *RASC* **13**, 193, 1919. Range 29 km. gd.
796	....	23.5	47 46	6.04	B9	Mt. Wilson, *ApJ* **35**, 173, 1912. Range 25 km. pr.
804	f Tau	25.4	12 36	4.28	K0	Moore, *LOB* **4**, 162, 1907. Orbit.
809	....	27.0	39.34	5.80	A	Young, *RASC* **13**, 193, 1919. Range 183 km. pr.

TABLE I—Continued.

Boss	Star	R.A. 1900		Decl.	Mag.	Class	Discoverer and Reference
816	τ^5 Eri	3^h	$29^m.4$	−21° 58′	4.32	B8	Frost, *ApJ* **25**, 63, 1907. Two spectra of equal brightness.
823	....		31.7	0 16	6.12	G0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Two spectra. Rel. vel. 118 km. G8.
826	....		33.5	62 54	5.32	Ma	Lick, *ASP* **34**, 168, 1922. Range 16 km.
836	11 Tau		34.8	25 0	6.15	A0	Plaskett, *RASC* **13**, 193, 1919. Range 63 km. fr.
839	ο Per		36.0	33 39	5.04	B2	Harper, *RASC* **13**, 237, 1919. Range 40 km. Σ 431.
841	13 Tau		36.6	19 23	5.50	B8	Mt. Wilson, *ApJ* **35**, 173, 1912. Range 68 km. pr.
842	....		37.3	63 2	4.96	F5	Miss Hobe, *LOB* **6**, 143, 1911. Range 9 km.
844	ο Per		38.0	31 58	3.94	B1	Adams, *ApJ* **15**, 215, 1902. Two spectra. Orbit.
846	δ For		38.3	−32 15	4.93	B5	Moore, *LOB* **6**, 4, 1910. Range 40 km. v. pr.
850	....		38.8	70 34	5.40	A0	Lick, *ASP* **34**, 168, 1922. Two spectra. Rel. vel. 50 km.
857	24 Eri		39.5	− 1 29	5.09	B8	Mt. Wilson, *ApJ* **35**, 174, 1912. Range 34 km. pr.
863	29 Tau		40.3	5 44	5.36	B3	Young, *DAO* **1**, 287, 1921. Range 44 km. pr. 1 plate shows two spectra.
864	....		40.4	65 13	4.71	Ma	Merrill, *LOB* **6**, 143, 1911. Range 6 km.
866	....		40.8	62 59	5.96	A3	Plaskett, *DAO* **1**, 163, 1920. Range 38 km. pr.
875	β Ret		42.9	−65 7	3.80	K0	Palmer, *LOB* **4**, 97, 1906. Range 7 km.
878	n Per		43.2	32 47	5.10	A2	Mt. Wilson, *ApJ* **35**, 174, 1912. Range 53 km. gd.
900	A Per		49.2	50 24	5.49	F5p	Lick, *ASP* **34**, 168, 1922. Two spectra.
902	33 Eri		49.5	−24 55	4.76	B5	Frost, *ApJ* **25**, 64, 1907. Two spectra suspected.
910	ε Per		51.1	39 43	2.96	B1	Frost, Adams, *ApJ* **19**, 151, 1904. Range 20 km. Two spectra.
913	ξ Per		52.5	35 30	4.05	Oe5	Frost, Adams, *ApJ* **18**, 388, 1903. Orbit.
920	λ Tau		55.1	12 12	var	B3	Belopolsky, *AN* **145**, 281, 1897. Two spectra. Algol var. Orbit.
923	36 Eri		55.7	−24 18	4.69	A0*p*	Frost, *AN* **177**, 174, 1908.
....	RW Tau		57.8	27 51	var	A0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 31 km. Algol var. Per. = $2^d.768904$.
....	DM 61°676 N		59.1	62 4	7.04	B0	*DAO*, 1924. Range 293 km.
....	DM 61°676 S		59.1	62 4	7.07	B0	*DAO*, 1924. Range 102 km.
943	41 Tau	4	0.5	27 20	5.27	A0p	Young, *RASC* **13**, 193, 1919. Range 30 km. gd.
947	c Per		1.4	47 27	4.03	B3p	Harper, *RASC* **13**, 237, 1919. Range 40 km. H brt.
961	....		6.0	5 16	5.71	F0	Young, *DAO* **1**, 287, 1921. Range 33 km. gd.
967	μ Per		7.6	48 9	4.28	G0	Campbell, *LOB* **6**, 143, 1911. Orbit.
970	f Per		8.1	40 14	4.89	F	Lick, *ASP* **30**, 352, 1918. Range 33 km. gd.
971	....		8.2	7 28	5.35	F0	H. Plaskett, *DAO* **1**, 287, 1921. Range 20 km. pr.
972	47 Tau		8.5	9 1	4.98	G5	Olivier, *LOB* **6**, 143, 1911. Range 4 km.
986	b^1 Per		10.7	50 3	4.57	A2	Curtis, *LOB* **5**, 174, 1910. Two spectra. Orbit.
....	C 570		11.9	16 42	8.3	G5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Taurus stream. Orbit.
992	b^2 Per		12.6	50 41	5.54	B3	Mt. Wilson, *ApJ* **35**, 174, 1912. Range 45 km. pr.
997	53 Tau		13.5	20 54	5.39	B8	Lick, *ASP* **34**, 168, 1922. Range 22 km. A5.
1000	γ Tau		14.1	15 23	2.86	K0	Miss Hobe, *LOB* **6**, 143, 1911. Range 6 km.
1001	υ Eri		14.1	−34 3	3.59	B9	Wright, *LOB* **3**, 110, 1905. Two spectra. Orbit.
1004	h Tau		14.3	13 48	5.59	F0	Plaskett, *RASC* **13**, 193, 1919. Range 55 km. A? pr.
1007	58 Tau		14.9	14 51	5.27	F0	Lee, *ApJ* **31**, 178, 1910. Taurus stream.
1013	60 Tau		16.4	13 50	5.76	A3	Young, *DAO* **1**, 163, 1920. Range 46 km. gd.
....	OΣ 82		17.1	14 49	7.0	F8	Joy, Adams, *ASP* **31**, 41, 1919. Btr. comp. vis. double. Orbit.
1018	63 Tau		17.7	16 33	5.68	A2	Schwarzschild, Sitz. k. Preussischen Ak. Wiss. 1913. p. 305. Orbit.
1022	64 Tau		18.3	17 13	4.84	A5	Lee, *ApJ* **29**, 240, 1909. Per 12^d or sub. mult. Taurus stream.
1033	69 Tau		20.3	22 35	4.40	A5	Frost, *ApJ* **29**, 239, 1909. Two spectra. pr. Taurus stream.
1034	71 Tau		20.6	15 23	4.60	A5	Lee, *ApJ* **29**, 241, 1909. Two spectra suspected.
1046	θ^2 Tau		22.9	15 39	3.62	F0	Moore, *LOB* **5**, 62, 1908. Two spectra. Orbit. Frost, *ApJ* **29**, 238, 1909. Taurus stream.
1051	80 Tau		24.4	15 25	5.70	F0	Young, *DAO* **1**, 163, 1920. Range 25 km. pr. Σ554.
1054	....		24.8	15 59	4.84	A5	Barrett, *ApJ* **29**, 237, 1909. Two spectra suspected. Taurus stream.
1058	....		26.2	15 38	6.04	F0	Plaskett, *DAO* **1**, 163, 1920. Range 16 km. pr.
1067	86 Tau		28.2	14 38	4.75	A5	Yerkes, *ApJ* **32**, 301, 1910. Two spectra. Taurus stream.
1068	....		28.4	28 45	5.70	B9	Plaskett, *DAO* **1**, 163, 1920. Range 19 km. fr.

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
1074	e Per	4^h $29^m.7$	41° 4′	4.46	K0 A3	Adams, Joy, *ASP* **30**, 185, 1918.
1076	88 Tau	30.2	9 57	4.38	A3	Moore, *LOB* **4**, 162, 1907. Two spectra. Orbit.
1079	ν Eri	31.3	− 3 33	4.12	B2	Frost, Adams, *ApJ* **17**, 151, 1903. *DO* Per. $0^d.1899$. Vel. system var.
....	SZ Tau	31.4	18 20	var	G0	Haynes, *LOB* **8**, 85, 1914. Orbit.
1082	3 Cam	32.0	52 53	5.31	K0	Adams, *ASP* **27**, 132, 1915. Orbit.
1085	....	32.4	20 29	5.73	B9	Young, *RASC* **13**, 194, 1919. Range 59 km. fr.
1087	90 Tau	32.6	12 19	4.30	A3	Barrett, *ApJ* **29**, 237, 1909. Two spectra suspected. *ApJ* **32**, 183, 1910. Taurus stream.
1090	92 Tau	33.6	15 43	4.85	A3	Lee, *ApJ* **29**, 242, 1909. Two spectra.
1091	53 Eri	33.6	−14 30	3.98	K0	Moore, *LOB* **5**, 62, 1908. Range 9 km.
1092	....	33.7	7 40	5.55	F0	Lee, *ApJ* **31**, 179, 1910. Range 7 km. Taurus stream.
1107	94 Tau	36.2	22 46	4.33	B5	Frost, Adams, *ApJ* **17**, 246, 1903. Orbit.
1110	α Cae	37.3	−42 3	4.52	F2	Paddock, *LOB* **6**, 143, 1911. Range 14 km.
1123	μ Eri	40.5	− 3 26	4.18	B5	Yerkes, *Sci* **32**, 876, 1910.
1122	....	40.5	11 31	5.43	A0	Plaskett, *DAO* **1**, 163, 1920. Range 17 km. gd.
1131	....	42.8	18 33	6.79	G5	Adams, Joy, *ASP* **29**, 113, 1917. Range 29 km.
....	SV Per	42.8	42 7	var	cF5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 16 km. Cepheid var.
1139	9 Cam	44.1	66 10	4.38	B0	Frost, Adams, *ApJ* **19**, 350, 1904. Orbit.
....	RX Eri	45.2	−15 55	var	F0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 40 km. Short var.
1143	97 Tau	45.5	18 40	5.12	F0	Lee, *ApJ* **29**, 241, 1909. Many lines complex. Jordan, *AO* **1**, 114, 1909.
1147	π_4 Ori	45.9	5 26	3.78	B3	Reese, *LOB* **2**, 29, 1903. Orbit.
1155	....	48.2	52 42	5.75	A2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 43 km. F1.
1159	π_5 Ori	49.0	2 17	3.87	B3	Frost, Adams, *ApJ* **17**, 150, 1903. Orbit.
1161	7 Cam	49.3	53 35	4.44	A2	Moore, *LOB* **4**, 162, 1907. Orbit.
....	SU Aur	49.6	30 24	var	F5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 36 km. Short var.
....	U Lep	52.0	−21 22	var	A	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 49 km. Per. $0^d.58144$. A4.
1177	98 Tau	52.0	24 54	5.65	B9	Adams, *ASP* **26**, 261, 1914. Range 48 km.
1178	ω Aur	52.5	37 44	4.99	A0	Merrill, *LOB* **6**, 143, 1911. Range 26 km.
....	RX Aur	54.5	39 49	var	G5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 12 km. Cepheid var. Per. $11^d.6263$.
1187	ε Aur	54.8	43 40	var	F5p	Vogel, *ApJ* **17**, 243, 1903. Ludendorff, *AN* **192**, 390, 1912, from light curve finds this star is an Algol variable, period 27.1 years. Also finds variation of velocity probably of long period. Does not confirm Vogel's suspicion of two spectra.
1190	ζ Aur	55.5	40 56	3.94	K0	Wright, *LOB* **5**, 62, 1908. Orbit.
1191	....	56.3	85 50	6.54	A5	H. Plaskett, *DAO* **1**, 287, 1921. Range 45 km. gd. F0.
1192	ψ Eri	56.6	− 7 19	4.81	B8	Wilson, *LOB* **6**, 144, 1911. Two spectra suspected.
1213	66 Eri	5 1.8	− 4 47	5.19	B9	Frost, *ApJ* **48**, 260, 1918. Two spectra. Orbit. Lick, *ASP* **30**, 351, 1918. Three spectra. Rel. vel. double lines 215 km.
1216	....	2.0	24 8	5.50	B3	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 76 km.
1219	....	2.5	8 22	5.47	F0p	Young, *DAO* **1**, 287, 1921. Range 14 km. gd.
....	TT Aur	2.8	39 28	var	B5	Adams, Joy, *ASP* **30**, 306, 1918. Two spectra. Rel. vel. 450 km. Algol var.
1229	14 Cam	4.2	62 34	6.38	A2	Harper, *DAO* **1**, 287, 1921. Range 56 km. pr.
1231	λ Eri	4.4	− 8 53	4.34	B2	Ottawa, unpublished. Range 92 km. pr.
1236	μ Aur	6.6	38 22	4.78	A3	Wilson, *LOB* **6**, 144, 1911. Range 23 km.
1240	ρ Ori	8.1	2 45	4.64	K0	Moore, *LOB* **5**, 62, 1908. Range 17 km.
1244	14 Aur	8.9	32 34	5.14	A2	Harper, *RASC* **10**, 165, 1916. Orbit.
1246	α Aur	9.3	45 54	0.21	G0	Campbell, *ApJ* **10**, 177, 1899. Newall, *MN* **60**, 2, 1899–1900. Two spectra. Orbit.
1249	....	9.7	34 12	5.81	B0p	Mt. Wilson, *ApJ* **35**, 174, 1912. Range 11 km. gd. Two spectra. B5 and probably A3.
1250	β Ori	9.7	− 8 19	0.34	B8p	Plaskett, *ApJ* **30**, 26 1909. Suspected by Vogel, Scheiner, *Ptm* **7**, 150, 1892. Orbit.

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
1253	15 Cam	5^h 10^m.8	58° 1′	6.23	B3	Young, *DAO* **1**, 287, 1921. Range 26 km. Two spectra on 2 plates.
1258	16 Aur	11.6	33 16	4.81	K0	Merrill, *LOB* **6**, 57, 1910. Range 26 km.
1262	τ Ori	12.8	− 6 57	3.68	B5	Frost, *ApJ* **25**, 64, 1907.
1269	θ Dor	13.8	−67 18	4.78	K0	Mrs. Moore, *LOB* **6**, 150, 1911. Range 16 km.
....	BD+37°1146	14.0	37 20	6.71	Oe5	Rufus, *ApJ* **51**, 252, 1920. Range 21 km.
1273	....	14.7	27 51	6.30	B9	Young, *RASC* **13**, 194, 1919. Range 65 km. fr.
1274	ρ Aur	14.7	41 42	5.12	B3	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 56 km. B5.
1275	....	14.8	29 28	5.72	A0	Adams, Joy, *ASP* **29**, 113, 1917. Two spectra. Orbit.
1276	16 Cam	14.9	57 27	5.25	A0	Plaskett, *DAO* **1**, 163, 1920. Range 18 km. fr.
1282	....	16.3	8 20	5.71	B2	Plaskett, *DAO* **1**, 287, 1921. Range 24 km. fr.
1284	ο Ori	16.7	− 0 29	4.65	B3	Frost, Adams, *ApJ* **18**, 383, 1903.
1301	η Ori	19.4	− 2 29	3.44	B1	Frost, Adams, *ApJ* **15**, 214, 1902. Two spectra. Orbit.
1303	γ Ori	19.8	6 16	1.70	B2	Frost, *ApJ* **31**, 431, 1910. Two spectra.
1314	ψ Ori	21.6	3 0	4.66	B2	Frost, Adams, *ApJ* **17**, 246, 1903. Two spectra. Orbit.
1315	114 Tau	21 6	21 51	4.83	B3	Henroteau, *DO* **5**, 64, 1921. Range 63 km. gd.
1333	χ Aur	26.2	32 7	4.88	B1	Frost, Adams, *ApJ* **18**, 383, 1903. Orbit.
1336	....	26.4	16 59	5.49	B9	Plaskett, *RASC* **13**, 194, 1919. Range 25 km. fr.
1337	....	26.4	16 59	6.8	A	Plaskett, *RASC* **13**, 194, 1919. Range 21 km. fr.
1339	δ Ori	26.9	− 0 22	2.48	B0	Deslandres, *CR* **130**, 379, 1900. Orbit.
1344	ε Col	27.7	−35 33	3.92	K0	Wright, *LOB* **6**, 153, 1911. Range 5 km.
1349	....	28.5	− 1 14	5.37	B2	Mt. Wilson, *ApJ* **35**, 174, 1912. Orbit.
1353	φ Ori	29.3	9 25	4.53	B0	Frost, Lee, *ApJ* **30**, 63, 1909. Quaternary system suspected.
1357	Σ 738 ftr.	29.6	9 52	5.56	Oe5	*DAO*, 1924. Range 29 km.
1364	42 Ori	30.4	− 4 54	4.65	B3	Frost, Lee, *ApJ* **30**, 64, 1909. H and K lines sharp. Two spectra suspected.
1363	θ^1 Ori C	30.4	− 5 27	5.36	Oe5	Frost, Adams, *ApJ* **19**, 152, 1904. Range 60 km.
1363	θ^1 Ori A	30.4	− 5 27	6.84	Oe5	Frost. *PA* **23**, 361, 1915.
1365	θ^2 Ori	30.5	− 5 29	5.17	B1	Frost, Adams, *ApJ* **19**, 152, 1904. Orbit.
1366	ι Ori	30.5	− 5 59	2.87	Oe5	Frost, Adams, *ApJ* **18**, 386, 1903. Orbit.
1367	....	30.6	56 18	6.89	F5	Harper, *DAO* **1**, 287, 1921. Range 23 km.
1369	....	30.9	26 52	5.70	B8	Young, *RASC* **13**, 194, 1919. Range 14 km. gd.
1370	ε Ori	31.1	− 1 16	1.75	B0	Frost, *ApJ* **29**, 235, 1909. Per. about 100 days or fraction of a day. Curtiss, *Det O* **1**, 132, 1915. Short period not indicated by Lick observations. Henroteau, *LOB* **9**, 178, 1918.
1375	ζ Tau	31.7	21 5	3.00	B3p	Frost, Adams, *ApJ* **17**, 150, 1903. Orbit.
1381	G Dor	32.4	−64 18	5.30	G5	Chile Sta. *LOB* **8**, 71, 1914. Orbit.
1384	β Dor	32.8	−62 33	3.81	F5p	Palmer, *LOB* **3**, 3, 1904. Orbit.
1388	125 Tau	33.5	25 50	5.00	B3	Lee, *ApJ* **39**, 40, 1914. Orbit.
1389	σ Ori	33.7	− 2 39	3.78	B0	Frost, Adams, *ApJ* **19**, 153, 1904. Range 21 km.
1391	ω Ori	33.9	4 4	4.54	B3p	Yerkes, *Sci* **32**, 876, 1910.
1392	d Ori	34.0	− 7 16	4.88	A3	Frost, *ApJ* **60**, 1924. Range 166 km. Two spectra.
1398	ζ Ori	35.7	− 2 0	2.05	B0	Mellor, *Det O* **3**, 66, 1917. Range 20 km. Per 19^d pr.
1399	....	35.8	− 1 11	5.00	B3	Frost, *ApJ* **23**, 264, 1906. Orbit.
1400	γ Men	35.8	−76 25	5.06	K0	Mrs. Moore, *LOB* **6**, 55, 1910. Range 6 km.
1410	....	38.1	56 5	6.06	A2	Plaskett, *DAO* **1**, 163, 1920. Range 71 km. pr.
1431	....	42.4	20 50	5.94	B9	Young, *DAO* **1**, 287, 1921. Range 76 km. pr.
1452	31 Cam	46.0	59 52	5.26	A0	Plaskett, *DAO* **1**, 163, 1920. Lick, *ASP* **34**, 168, 1922. Two spectra. Orbit.
1455	....	46.7	14 9	5.57	B9	Young, *DAO* **1**, 163, 1920. Range 17 km. gd.
1457	136 Tau	47.0	27 35	4.54	A0	Lows, *LOB* **6**, 144, 1911. Two spectra. Orbit.
1468	α Ori	49.8	7 23	0.92	Ma	Plummer, *ASP* **20**, 227, 1908. Light var. Orbit.
1471	....	50.4	67 0	6.87	A0	H. Plaskett, *DAO* **1**, 287, 1921. Range 25 km. pr. A3.
1475	139 Tau	51.8	25 56	4.90	B2	Frost, Lee, *ApJ* **30**, 64, 1909. Two spectra suspected.
1477	ξ Col	52.1	−37 8	5.02	K0	Mrs. Moore, *LOB* **6**, 55, 1910. Range 9 km.
1478	β Aur	52.2	44 56	2.07	A0p	Miss Maury, 4th Rep. *DM* 9, 1890. Two spectra. Orbit.
1488	60 Ori	53.7	0 32	5.25	A0	Lick, *ASP* **36**, 145, 1924. Range 13 km. gd.
1492	2 Mon	54.3	− 9 34	5.10	A5	Barrett, *PA* **22**, 234, 1914. Orbit.
1501	μ Ori	56.9	9 39	4.19	A2	Frost, *ApJ* **23**, 264, 1906. Also visual binary. Aitken, *LOB* **8**, 93, 1914. Orbits.
1503	3 Mon	57.1	−10 36	4.97	B8	Wilson, *LOB* **6**, 144, 1911. Range 33 km.
1504	64 Ori	57.5	19 42	5.17	B8	Lick, *ASP* **34**, 168, 1922. Two spectra.
1507	χ Ori	58.0	20 8	4.71	B2p	Merrill, *LOB* **6**, 144, 1911. Range 14 km.
1508	1 Gem	58.0	23 16	4.30	G5	Moore, *LOB* **4**, 96, 1906. Orbit.

TABLE I—Continued.

Boss	Star	R.A., 1900		Decl.	Mag.	Class	Discoverer and Reference
1515	40 Aur	5^h	59^m7	38° 29′	5.31	A3	Lee, *ApJ* **39**, 40, 1914. Two spectra. Orbit.
1516	17 Lep	6	0.5	−16 29	5.04	A0	Chile Sta. *LOB* **8**, 81, 1914. Range 64 km. gd. Composite spectrum suspected.
1518	....		0.7	23 39	6.89	K0	Plaskett, *DAO* **1**, 287, 1921. Range 10 km.
1525	ν Ori		1.9	14 47	4.40	B2	Frost, Adams, *ApJ* **18**, 383, 1903. Orbit.
....	DM 20°1284		3.7	20 31	7.40	Oe5	*DAO*, 1924. Range 33 km.
1548	ξ Ori		6.3	14 14	4.35	B3	Frost, Adams, *ApJ* **19**, 150, 1904. Range 22 km.
1556	22 Cam		7.8	69 21	4.73	A0	Hnatek, *AN* **210**, 246, 1919. Two spectra. Rel. vel. 175 km.
1558	δ Pic		8.4	−54 57	4.84	B1	Chile Sta. *LOB* **8**, 124, 1914. Range 342 km. pr.
1559	....		8.6	17 56	5.74	A5	Young, *DAO* **1**, 163, 1920. Range 32 km. fr.
1561	η Gem		8.8	22 32	var	Ma	Reese, *LOB* **1**, 158, 1902.
1593	45 Aur		13.6	53 30	5.41	F5	Lick, *ASP* **34**, 168, 1922. Orbit.
1594	....		13.9	−19 56	5.31	B3	Chile Sta. *LOB* **8**, 81, 1914. Range 51 km. fr.
....	RS Ori		16.5	14 44	var	cF8	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 42 km. Cepheid var.
1601	ζ C Ma		16.5	−30 1	3.70	B3	Paddock, *LOB* **5**, 60, 1908. Range 27 km.
1606	ψ Aur		17.2	49 20	5.10	K2	Olivier, *LOB* **6**, 145, 1911. Range 6 km.
1607	....		18.0	56 20	5.50	A3	Mt. Wilson, *ApJ* **35**, 175, 1912. Orbit.
1609	β C Ma		18.3	−17 54	1.99	B1	Albrecht, *LOB* **5**, 62, 1908. Orbit.
1610	δ Col		18.4	−33 23	3.98	G5	Palmer, *LOB* **3**, 110, 1905. Orbit.
....	T Mon		19.8	7 8	var	G5p	Frost, *ApJ* **23**, 264, 1906. Cepheid var. Per. 27^d0122.
....	DM 14°1296		21.6	14 57	7.09	Oe5	*DAO*, 1924. Range 91 km.
1629	RT Aur		22.1	30 33	var	G0	Duncan, *LOB* **5**, 86, 1908. Orbit.
1635	ν Gem		23.0	20 17	4.06	B5	Yerkes, *ApJ* **32**, 301, 1910. Orbit.
....	DM 11°1204		25.6	11 19	5.83	B0	*DAO*, 1924. Range 48 km.
1646	WW Aur.		25.9	32 32	5.98	A0	Joy, *ASP* **30**, 254, 1918. Two spectra. A7, Algol var. Orbit.
....	DM 4°1291		26.0	4 54	7.96	B0	*DAO*, 1924. Range 16 km.
1649	Σ 924 pr.		26.4	17 51	6.72	F8	H. Plaskett, *DAO* **1**, 287, 1921. Range 23 km.
1660	ξ C Ma		27.7	−23 21	4.35	B1	Frost, *ApJ* **25**, 64, 1907. β C. Maj. type, Henroteau, *DO* **5**, 67, 1921.
1667	22 Gem		28.8	19 30	6.88	A0	Harper, *DAO* **1**, 287, 1921. Two spectra. Rel. vel. 153 km.
1669	47 C Ma		28.9	−31 57	5.70	B3	Curtis, *LOB* **5**, 139, 1909. Range 36 km.
....	W Gem		29.2	15 24	var	G5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 32 km. Cepheid var. Per. 7^d91603.
1690	γ Gem		31.9	16 29	1.93	A0	Burns, *LOB* **3**, 84, 1905. Orbit.
....	BD 6°1309		32.0	6 13	6.06	B0p	Plaskett, *RASC* **16**, 284, 1922. Two spectra. Orbit.
....	DM 5°1334		32.5	5 3	6.16	B1	*DAO*, 1924. Range 37 km.
1702	ν Pup		34.7	−43 6	3.18	B8	Wright, *LOB* **5**, 61, 1908. Range 15 km. Two spectra suspected.
1706	S Mon		35.5	9 59	4.68	Oe5	Frost, Adams, *ApJ* **19**, 151, 1904. Range 30 km.
1714	....		36.6	17 45	5.14	A0	Plaskett, *DAO* **1**, 163, 1920. Range 32 km. pr.
....	DM 6°1351		36.6	6 27	6.20	B2	*DAO*, 1924. Range 23 km.
1730	42 Cam		40.5	67 41	5.04	B3	Yerkes, *ApJ* **32**, 302, 1910. Two spectra.
1732	α C Ma		40.7	−16 35	−1.58	A0	Campbell, *LOB* **3**, 80, 1905. Vis. double. Aitken's elements of visual system $P=50^y04$, $e=0.59$, $i=+43.3$. Campbell finds *i* positive. Four Lick observations, 1909.6, $V=-7.98$ km. Mt. Wilson, 1910.0, $V=-7.82$ km. Mean resulting $V_0=-7.6$ km. Münch suggests a triple system. *AN* **186**, 226, 1910.
1733	16 Mon		41.1	8 42	5.84	B3	*DAO*, 1924. Range 35 km.
1740	18 Mon		42.6	2 31	4.70	K0	Lick, *ASP* **34**, 168, 1922. Range 8 km.
1754	....		44.4	−15 2	5.29	B5	Chile Sta. *LOB* **8**, 72, 1914. Range 106 km. pr.
1758	....		45.5	77 6	4.75	K5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 19 km. Member of Praesepe Cluster.
1763	θ Gem		46.2	34 5	3.64	A2	Hnatek, *AN* **196**, 391, 1913.
1772	τ Pup		47.5	−50 30	2.83	K0	Curtis, Palmer, *LOB* **5**, 60, 1908. Range 7 km.
1773	A Car		47.7	−53 30	4.38	G5	Wright, *LOB* **3**, 111, 1905. Orbit.
1807	....		57.0	−25 4	5.80	B3	Chile Sta. *LOB* **9**, 38, 1916. Range 67 km. gd.
1815	ζ Gem		58.2	20 43	var	G0p	Belopolsky in unpublished lecture; see *AN* **149**, 239, 1899. Campbell-Wright, *ApJ* **9**, 86, 1899. Cepheid var. Orbit.
1817	24 o^2 C Ma		58.8	−23 41	3.12	B5p	Mitchell, *ApJ* **30**, 242, 1909. App. Per. 24^d27 Curtis, *LOB* **6**, 57, 1910.
1826	C Pup	7	0.9	−42 11	5.26	A2	Chile Sta. *LOB* **8**, 72, 1914. Two spectra. Rel. vel. 73 km.

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
....	HD 54371	$7^{\mathrm{h}}\ 3^{\mathrm{m}}5$	25° 54′	7.01	G0	Sanford, *ApJ* **56**, 446, 1922. Orbit.
1839	δ C Ma	4.3	−26 14	1.98	F8p	Wright, *LOB* **5**, 177, 1910. Range 3 km. Per. ¾ year. Lunt, *ApJ* **48**, 271, 1918, questions binary character.
1845	A Pup	5.5	−39 30	4.85	B3	Paddock, *LOB* **6**, 150, 1911. Range 11 km. fr.
1863	E Pup	9.0	−40 20	5.40	A2	Chile Sta. *LOB* **9**, 37, 1916. Range 66 km.
1866	γ_1 Vol	9.6	−70 20	5.81	G0	Campbell, *LOB* **6**, 145, 1911. Range 9 km.
1872	27 C Ma	10.2	−26 11	4.66	B5p	Paddock, *LOB* **6**, 4, 1910. Range 30 km.
1877	ω C Ma	10.8	−26 36	3.83	B3p	Paddock, *LOB* **6**, 150, 1911. Range 22 km. pr. Bright double hydrogen lines.
....	RU Cam	10.9	69 52	var	var	Joy, *ASP* **31**, 180, 1919. Range 45 km. Cepheid variable. Spectrum varies Ko—Ro.
1886	λ Gem	12.3	16 43	3.65	A2	Hnatek, *AN* **195**, 173, 1913. Lee, *ApJ* **60**, 1924. Range 144 km.
1891	....	13.3	−36 25	5.01	B3	Paddock, *LOB* **5**, 139, 1909. Range 45 km. Two spectra suspected.
1898	δ Gem	14.2	22 10	3.51	F0	Hnatek, *AN* **195**, 174, 1913.
1899	29 C Ma	14.5	−24 23	4.90	Oe	Frost, *ApJ* **23**, 264, 1906. Orbit.
1901	τ C Ma	14.6	−24.46	4.40	Oe5	Frost, *ApJ* **23**, 265, 1906. Two spectra suspected. Frost, Lee, *ApJ* **60**, 1924. Range 92 km.
1906	19 Lyn	14.7	55 28	5.61	B8	Mt. Wilson, *ApJ* **35**, 175, 1912. Two spectra. Orbit.
1909	R C Ma	14.9	−16 12	var	F0	Frost, *ApJ* **22**, 213, 1905. Algol var. Orbit.
1910	v_2 Pup	15.1	−36 34	5.11	B3	Chile Sta. *LOB* **8**, 124, 1914. Range 20 km. fr.
....	RR Gem	15.2	31 4	var	A8	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 51 km.
1928	21 Lyn	19.2	49 25	4.45	A0	Barrett, *PA* **22**, 233, 1914. Range 15 km.
1945	63 Gem	21.8	21 39	5.27	F5	Lick, *ASP* **34**, 168, 1922. Two spectra.
1953	γ C Mi	22.7	9 8	4.60	K0	Reese, *LOB* **1**, 159, 1902.
1959	b Gem	23.6	28 7	5.09	K0	Lick, *ASP* **34**, 168, 1922, Range 9 km.
1972	σ Pup	26.1	−43 6	3.27	K5	Palmer, *LOB* **3**, 111, 1905. Orbit.
1979	α_1 Gem	28.2	32 6	2.85	A0	Belopolsky, *BAS St Pet*, Jan. 1897. Orbit.
1979	α_2 Gem	28.2	32 6	1.99	A0	Curtis, *LOB* **3**, 84, 1905. Orbit.
....	....	28.2	32 6	9.5	Md	Adams, Joy, *ASP* **32**, 158, 1920. Two spectra. Rel. vel. 230 km. Spectra K8, except that hydrogen lines are bright and sharp. Companion to *Castor*.
....	HD 60848	31.4	17 7	7.7	Oe5	*DAO*, 1924. Range 25 km.
2013	....	34.8	5 28	5.81	A0	Young, *DAO* **1**, 163, 1920. Range 36 km. fr.
2022	....	36.5	50 40	5.28	A0	Plaskett, *DAO* **1**, 163, 1920. Range 44 km. pr.
2023	σ Gem	37.1	29 8	4.26	K0	Reese, *LOB* **2**, 29, 1903. Orbit.
2026	....	37.8	−38 18	5.48	B2	Chile Sta. *LOB* **8**, 124, 1915. Range 46 km. gd.
2035	l_3 Pup	39.8	−28 43	4.10	A2p	Olivier, *LOB* **6**, 145, 1911. Range 10 km. pr.
2040	g Gem	40.3	18 45	5.02	K2	Lick *ASP* **34**, 168, 1922. Range 12 km.
2045	11 C Ma	40.8	11 1	5.30	A0	Struve, *ApJ* **60**, 1924. Range 57 km.
2062	....	44.5	−46 22	5.26	B2	Chile Sta. *LOB* **9**, 39, 1916. Range 80 km. pr.
2067	Q Pup	45.3	−46 50	4.64	K0	Mrs. Moore, *LOB* **6**, 150, 1911. Range 8 km.
2078	φ Gem	47.4	27 1	4.99	A2	Yerkes, *ApJ* **32**, 302, 1910. Two spectra.
2085	....	48.4	56 46	6.49	A0	Young, *DAO* **1**, 287, 1921. Range 34 km. fr.
2087	a Pup	48.8	−40 19	3.76	G5	Wright, *LOB* **3**, 111, 1905.
2089	b Pup	49.1	−38 36	4.53	B3	Chile Sta. *LOB* **8**, 125, 1914. Range 95 km. pr.
2109	....	53.7	−43 14	5.42	B3	Chile Sta. *LOB* **8**, 125, 1914. Range 70 km. pr.
2112	54 Cam	54.5	57 33	6.52	G0	Harper, *DAO* **1**, 287, 1921. Two spectra. Rel. vel. 132 km.
2114	O Pup	54.7	−45 18	5.16	K5	Chile Sta. *ASP* **34**, 168, 1922. Range 24 km.
2119	V Pup	55.4	−48 58	4.50	B1p	Pickering, *HCO Circ*, No. 14, 1896. Two spectra. Orbit.
2131	χ Gem	57.4	28 4	5.04	K0	Lick, *ASP* **36**, 145, 1924. Range 8 km.
2142	28 Lyn	8 0.2	43 33	6.24	A0	Harper, *DAO* **1**, 163, 1920. Two spectra Rel. vel. 152 km. fr.
2153	ι Arg	3.3	−24 1	2.88	F5	Campbell, *LOB* **2**, 29, 1903.
2166	γ^1 Vel	6.4	−47 3	4.79	B3	Moore, *LOB* **6**, 150, 1911. Range 77 km. pr.
2173	15 Cnc	6.9	29 57	5.59	A0p	Young, *DAO* **1**, 163, 1920. Range 35 km. gd.
2179	ϵ Vol	7.6	−68 19	4.46	B5	Curtis, *LOB* **5**, 139, 1909. Orbit.
2180	h^1 Pup	7.8	−39 19	4.43	K5	Mrs. Moore, *LOB* **6**, 55, 1910. Range 9 km.
2191	AGC 10986	10.5	−46 41	5.28	B3	Chile Sta. *ASP* **34**, 168, 1922. Range 79 km.
2192	h^2 Pup	10.5	−40 3	4.43	K0	Mrs. Moore, *LOB* **6**, 55, 1910. Range 13 km.
2193	57 U Ma	10.6	62 49	5.77	G0	Adams, Joy, *ASP* **29**, 113, 1917.
2206	λ Cnc	14.6	24 20	5.87	A0	Harper, *DAO* **1**, 287, 1921. Range 41 km. pr.
2227	1 Hya	19.6	− 3 26	5.67	F5	H C. Wilson, *ApJ* **55**, 30, 1922. Orbit.

TABLE I—Continued.

Boss	Star	R.A., 1900		Decl.	Mag.	Class	Discoverer and Reference
2228	κ_1 Vol	8^{h}	$20^{m}1$	−71° 12′	5.44	B9	Chile Sta. *LOB* **8**, 81, 1914. Two spectra.
2251	28 Cnc		22.7	24 29	6.06	A5	Young, *DAO* **1**, 163, 1920. Range 18 km. pr.
2266	A Vel		25.9	−47 36	5.52	B5	Chile Sta. *LOB* **7**, 96, 1912. Range 36 km. pr.
2267	34 Vel		26.1	−44 23	5.06	B5	Chile Sta. *LOB* **8**, 125, 1914.
2285	....		30.5	6 58	6.04	F5	Adams, Joy, *ASP* **31**, 41, 1919. Comp. of Σ 1245. Orbit.
....	HD 73618		34.2	19 54	6.94	A0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. A6. Two spectra. Rel. vel. 165 km. Member Praesepe cluster.
....	HD 73709		34.6	20 3	8.7	A0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 26 km. Member of Praesepe cluster. F0.
2311	....		34.7	19 54	6.32	A2	Young, *DAO* **1**, 287, 1921. Two spectra. Rel. vel. 105 km. fr.
....	HD 73871		35.5	20 50	6.60	A2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 50 km. Member of Praesepe cluster. A3.
....	Harvard 72		35.6	19 37	8.6	A5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 37 km. Member of Praesepe cluster.
2322	54 Vel		37.1	−52 42	5.38	B5	Chile Sta. *LOB* **8**, 72, 1914. Range 116 km. fr.
2324	b Vel		37.3	−46 18	4.06	F5p	Chile Sta. *LOB* **8**, 72, 1914. Range 14 km. pr.
2325	*o* Vel		37.4	−52 34	3.68	B3	Curtis, *LOB* **5**, 60, 1908. Range 20 km.
2327	γ Cnc		37.5	21 50	4.73	A0	Yerkes, *ApJ* **32**, 302, 1910. Two spectra suspected.
2329	n Vel		37.9	−46 58	4.85	A3	Chile Sta. *LOB* **7**, 96, 1912. Range 14 km. gd.
2330	η Hya		38.0	3 45	4.32	B3	Frost, Adams, *ApJ* **19**, 151, 1904.
2331	d Car		38.4	−59 24	4.43	B2	Paddock, *LOB* **5**, 60, 1908. Range 34 km.
2354	ϵ Hya		41.5	6 47	3.48	F8	Campbell, *LOB* **1**, 23, 1901. Vis. double. Orbit.
2354	ϵ Hya C		41.5	6 47	7.5	F5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 78 km.
2355	D Hya		41.7	−13 11	4.44	G5	Miss Hobe, *LOB* **6**, 145, 1911. Range 9 km.
2361	ρ Hya		43.1	6 12	4.42	A0	Barrett, *ApJ* **60**, 1924. Suspects more than one spectrum. Per. probably short.
2376	g Vel		46.3	−44 56	5.02	A2	Mrs. Moore, *LOB* **6**, 151, 1911. Range 32 km.
2377	51 Cnc		46.4	32 51	5.75	A3	Young *DAO* **1**, 287, 1921. Range 44 km. fr.
2381	15 Hya		46.7	− 6 48	5.60	A2	Adams, *ASP* **26**, 261, 1914. Range 46 km.
2382	f Vel		47.1	−46 9	4.89	B0	Moore, *LOB* **7**, 96, 1912. Range 51 km. pr.
2383	....		48.1	64 59	5.62	G5	Young, *DAO* **1**, 287, 1921. Range 15 km. gd.
2395	84 Vel		50.5	−47 8	5.32	A5	Chile Sta. *LOB* **8**, 73, 1914. pr. Two spectra suspected. Rel. vel. 84 km.
2408	H Vel		53.3	−52 20	4.77	B5	Paddock, *LOB* **5**, 139, 1909. Range 71 km.
2415	....		54.5	84 35	6.26	F0	Harper, *DAO* **1**, 287, 1921. Two spectra. Rel. vel. 106 km. pr.
2420	68 Cnc		56.1	17 28	7.11	B9	H. Plaskett, *DAO* **1**, 287, 1921. Range 73 km. pr.
2421	w Vel		56.3	−40 52	4.42	F8	Palmer, *LOB* **3**, 3, 1904. Orbit.
2432	....		58.5	48 56	5.59	F5	Plaskett, *DAO* **1**, 163, 1920. Range 25 km. pr.
2440	α Vol	9	0.9	−66 0	4.18	A5	Wright, *LOB* **3**, 111, 1905. Two spectra.
2445	κ Cnc		2.3	11 4	5.14	B8	Frost, Adams, *ApJ* **19**, 350, 1904. Two spectra. Orbit.
2446	τ U Ma		2.7	63 55	4.74	A5	Moore, Burns, *LOB* **4**, 68, 1906. Range 9 km.
2447	75 Cnc		2.9	27 3	5.96	G5	Adams, Joy, *ASP* **31**, 41, 1919. Orbit. F.
2449	ξ Cnc		3.6	22 27	5.22	G5	Lick, *ASP* **34**, 168, 1922. Range 8 km.
2462	80 Cnc		6.3	18 27	6.75	A0	H. Plaskett, *DAO* **1**, 287, 1921. Range 51 km. pr.
2463	c U Ma		6.4	61 50	5.23	F8	Young, *DAO* **1**, 163, 1920. Lick *ASP* **34**, 168, 1922. Orbit.
2473	a Car		8.4	−58 33	3.56	B3	Wright, *LOB* **3**, 111, 1905. Two spectra suspected. Orbit.
2476	18 U Ma		9.0	54 26	4.89	A5	Allegheny, *ApJ* **39**, 265, 1914.
2479	22 Hya		9.2	2 44	3.84	A0	Campbell, Albrecht, *LOB* **5**, 174, 1910. Range 27 km. Lee, *ApJ* **32**, 303, 1910. Two spectra suspected.
2484	....		10.8	47 14	5.70	A0	Adams, *Sci* **37**, 643, 1913. Two spectra. Orbit.
2490	23 Hya		11.7	− 5 56	5.40	K0	Lick, *ASP* **34**, 168, 1922. Orbit.
2504	K Vel		14.8	−50 38	5.34	B9	Chile Sta. *LOB* **9**, 39, 1916. Range 95 km.
....	HD 80715		16.2	40 38	7.71	K2	Adams, *ASP* **26**, 261, 1914. Range 38 km. Composite spectrum.
2522	21 U Ma		18.6	54 27	7.36	A2	H. Plaskett, *DAO* **1**, 287, 1921. Two spectra. Rel. vel. 98 km. pr.
2526	κ Vel		19.0	−54 35	2.63	B3	Wright, *LOB* **3**, 111, 1905. Orbit.
....	H.D 81976		24.0	33 45	8.1	A0	Adams, *ASP* **27**, 132, 1915. Two spectra. Rel. vel. 125 km. A2p.
2551	....		26.1	−71 10	5.48	K0	Chile Sta. *ASP* **34**, 168, 1922. Range 13 km.
....	S Ant		27.9	−28 11	var	F0	Adams, Joy, *ASP* **31**, 41, 1919. Cepheid var. Orbit.
2577	L Vel		30.7	−50 49	5.16	B3	Chile Sta. *LOB* **8**, 73, 1914. Range 150 km. pr.

TABLE I—Continued.

Boss	Star	R.A., 1900		Decl.	Mag.	Class	Discoverer and Reference
2582	1 Sex	9^h	31^m9	7° 17′	5.14	K0	Lick, *ASP* **34**, 168, 1922. Range 11 km.
2602	ο Leo		35.8	10 21	3.76	F5	Campbell, *ApJ* **8**, 291, 1898. Two spectra Orbit..
....	W U Ma		36.7	56 25	var	G0	Adams, Joy, *ApJ* **49**, 189, 1919. Two spectra. F8p. Orbit.
2606	ζ Cha		36.8	−80 30	5.24	B3	Chile Sta. *LOB* **8**, 125, 1915. Range 24 km. gd. H, He.
2607	....		37.6	−57 32	5.36	A2	Chile Sta. *LOB* **8**, 74, 1914. Range 38 km. fr.
2628	l Car		42.5	−62 3	var	Go	Wright, *LOB* **3**, 3, 1904. Cepheid var. Orbit.
2634	20 Leo		44.2	21 39	6.01	F0	Plaskett, *DAO* **1**, 163, 1920. Range 30 km. Two spectra.
2644	17 L Mi		46.3	38 23	6.74	F0	Plaskett, *DAO* **1**, 287, 1921. Range 28 km. pr.
2651	m Vel		47.8	−46 5	4.56	G5	Wright, *LOB* **4**, 97, 1906. App. orbit.
2665	19 L Mi		51.6	41 32	5.19	F5	Lick *ASP* **34**, 168, 1922. Orbit.
2672	ν Leo		52.8	12 55	5.18	A0	Plaskett, *DAO* **1**, 163, 1920. Range 33 km.
2678	12 Sex		54.5	3 52	6.63	A5	H. Plaskett, *DAO* **1**, 287, 1921. Range 68 km. pr.
....	RR Leo	10	2.1	24 29	var	A9	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 49 km.
2706	λ Hya		5.7	−11 52	3.83	K0	Wright, Burns, *LOB* **4**, 68, 1906. Range 9 km.
....	HD 88512		7.4	50 59	6.63	A3	Adams, Joy, *ASP* **29**, 113, 1917.
2723	q Vel		10.5	−41 38	4.09	A2	Paddock, *LOB* **5**, 61, 1908. Range 26 km.
2730	ζ Leo		11.1	23 55	3.65	F0	Wilson, *LOB* **6**, 145, 1911. Range 20 km. pr.
2751	μ U Ma		16.4	42 0	3.21	K5	Moore, *LOB* **4**, 68, 1906. Range 10 km.
2754	30 U Ma		16.9	66 4	4.92	A0	Schlesinger, Baker, *AO* **1**, 121, 1909. Orbit.
2757	....		17.8	7 3	6.28	K0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 22 km. K2.
2767	L Car		20.0	−66 24	5.28	B8	Chile Sta. *LOB* **7**, 97, 1912. Two spectra. Rel. vel. 123 km.
2790	δ Ant		25.0	−30 6	5.65	B9	Curtis, *LOB* **6**, 55, 1910. Two spectra. Rel. vel. 140 km.
2824	36 L Mi		32.2	34 36	6.65	K0	H. Plaskett, *DAO* **1**, 287, 1921. Range 9 km.
2830	p Vel		33.1	−47 42	4.06	F2	Wright, *LOB* **3**, 111, 1905. Two spectra. Orbit.
2836	φ Hya		33.7	−16 21	5.11	K0	Lick, *ASP* **30**, 353, 1918. Range 10 km.
2862	θ Car		39.4	−63 52	3.03	B0	Chile Sta. *LOB* **8**, 125, 1915. Range 70 km. pr.
2866	42 L Mi		40.3	31 13	5.37	B9	Mt. Wilson, *ApJ* **35**, 175, 1912. Range 49 km. pr.
2874	38 Sex		42.1	6 52	7.01	A2	Harper, *DAO* **1**, 287, 1921. Two spectra. Rel. vel. 107 km. pr.
2883	l Leo		44.0	11 4	5 27	A0	Barrett, *ApJ* **60**, 1924. Range 210 km. Two spectra. Per. = 0^d7 by Struve.
2900	ω U Ma		48.2	43 43	4.84	A0	Vogel, *AN* **163**, 145, 1903. Two spectra. Orbit.
2931	p^2 Leo		56.7	− 1 57	4.97	Ma	Lick, *ASP* **36**, 145, 1924. Range 7 km.
2933	α U Ma		57.6	62 17	1.95	K0	Campbell, *LOB* **5**, 174, 1910. Range 6 km.
2948	χ_2 Hya	11	1.1	−26 45	5.69	B8	Chile Sta. *LOB* **9**, 39, 1916. Range 201 km.
....	HD 965111		2.2	82 17	7.06	G0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. G1
2951	64 Leo		2.3	23 52	6.39	A2	Adams, *ASP* **27**, 132, 1915. Range 45 km. Young, *DAO* **1**, 163, 1920.
2953	....		2.5	86 11	7.17	A2	H. Plaskett, *DAO* **1**, 287, 1921. Range 19 km. gd.
2960	x Car		4.3	−58 26	4.02	F8p	Wright, *LOB* **4**, 161, 1907. Range 14 km.
2964	β Crt		6.7	−22 17	4.52	A2	Paddock, *LOB* **5**, 139, 1909. Range 22 km. gd.
2984	ξ U Ma s. f. ftr.		12.9	32 6	4.87	G0	Lick, *ASP* **30**, 353, 1918. Per. about 10 d.
2984	ξ U Ma n. p. btr.		12.9	32 6	4.41	G0	Wright, *ApJ* **12**, 254, 1900. Orbit.
2987	55 U Ma		13.7	38 44	4.78	A2	Lee, *Sci* **28**, 853, 1908. Two spectra. Orbit.
2990	77 Leo		16.0	6 35	4.13	A0	Yerkes, *ApJ* **32**, 303, 1910. Complex lines. Cannon, *DO* **1**, 434, 1913, finds period 17 d. satisfies most observations but not all.
2996	26 Cen		18.4	−35 37	5.12	K5	Chile Sta. *ASP* **34**, 168, 1922. Range 10 km.
2997	λ Crt		18.4	−18 14	5.15	F2	Lick, *ASP* **34**, 168, 1922. Range 14 km.
3009	82 Leo		20.5	3 51	6.70	A2	Harper, *DAO* **1**, 287, 1921. Range 36 km. pr.
3013	....		21.4	−63 25	5.34	F5	Chile Sta. *LOB* **9**, 37, 1916. Two spectra. Rel. vel. 52 km.
3023	57 U Ma		23.7	39 53	5.26	A2	Barrett, Struve, *ApJ* **60**, 1924. Range 80 km. Per. 12h.
3024	....		23.8	−42 7	5.34	B9	Chile Sta. *LOB* **8**, 74, 1914. Range 69 km. 4481, gd.
.. ..	HD 100018		25.4	41 52	6.99	F5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Two spectra. Rel. vel. 105 km. β G C 5805.
3035	o^1 Cen		27.1	−58 53	4.96	F8p	Chile Sta. *ASP* **34**, 168, 1922. Range 13 km.
....	SU Dra		32.2	67 53	var	A2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 43 km. Per. 0^d3978. A5.
3069	Σ1561 ftr.		33.5	45 40	8.6	K4	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 47 km.
....	C 1435		33.7	42 52	8.4	K2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 56 km. K3.
3071	....		34.8	−64 51	5.08	A0	Chile Sta. *LOB* **8**, 74, 1914. Range 19 km. G0.
3076	....		36.2	−61 32	4.88	G0	Paddock, *LOB* **5**, 139, 1909. Range 18 km.
3098	93 Leo		42.8	20 46	4.54	F8	Campbell, Wright, *ApJ* **12**, 255, 1900. Orbit.
3102	.. . .		44.5	35 29	5.76	F5	Plaskett, *DAO* **1**, 163, 1920. Range 42 km. gd.

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
3108	....	11^{h} $45^{m}9$	− 4° 47′	5.81	K0	Adams, *ASP* **27**, 132, 1915. Range 28 km. K5.
3123	o Leo	50.5	16 12	5.49	A2	Mt. Wilson, *ApJ* **35**, 175, 1912. Range 86 km. fr.
3139	π Vir	55.7	7 10	4.57	A2	Albrecht, *LOB* **5**, 175, 1910. Range 38 km.
3138	31 Crv	55.7	−19 6	5.28	B3	Mt. Wilson, *ApJ* **35**, 176, 1912. Orbit.
3146	θ^1 Cru	57.9	−62 45	4.48	A5	Mrs. Moore, *LOB* **6**, 56, 1910. Orbit. Two spectra.
3150	2 Com	59.2	22 1	5.77	F0	Mt. Wilson, *Sci* **37**, 643, 1913. Range 53 km.
3151	θ^2 Cru	59.2	−62 36	4.98	B3	Paddock, *LOB* **5**, 139, 1909. Range 66 km.
3180	....	12 6.8	26 26	5.81	K0	H. Plaskett, *DAO* **1**, 287, 1921. Range 26 km.
....	S Mus	7.4	−69 36	var	F8p	Paddock, *LOB* **9**, 68, 1917. Cepheid var.
3182	4 Dra	7.5	78 10	5.12	A5	Lee, *AN* **194**, 416, 1913. Orbit.
3184	D Cen	8.8	−45 10	5.29	K0	Chile Sta. *ASP* **34**, 168, 1922. Range 9 km.
....	HD 106515	10.0	− 6 41	7.42	G5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 29 km. β GC 6090. G8.
3191	γ Crv	10.7	−16 59	2.78	B8	Campbell, Curtis, *LOB* **2**, 126, 1903.
3192	6 Com	10.9	15 27	5.08	A2	Barrett, *PA* **22**, 233, 1914. Two spectra.
3195	....	11.5	33 37	5.08	K0	Lick, *ASP* **34**, 169, 1922. Range 12 km.
3197	ϵ Mus	12.2	−67 24	4.16	Mb	Curtis, *LOB* **6**, 145, 1911. Range 11 km.
....	SW Dra	13.1	70 4	var	F4	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 82 km.
3203	F Cen	13.7	−54 35	4.98	Ma	Mrs. Moore, *LOB* **6**, 151, 1911. Range 14 km.
3210	η Vir	14.8	− 0 7	4.00	A0	Frost, Adams, *ApJ* **17**, 152, 1903. Orbit. Campbell, Curtis, *LOB* **2**, 126, 1903. Two spectra.
3224	12 Com	17.5	26 24	4.78	F5	Merrill, *LOB* **6**, 57, 1910. Composite spectrum.
....	HD 107760	17.9	73 48	8.2	G5	Sanford, *ApJ* **56**, 446, 1923. Two spectra. Orbit.
3230	5 C Vn	19.2	52 7	4.97	K0	Wilson, *LOB* **6**, 146, 1911. Range 3.3 km. Küstner, range 11.0 km.
3236	....	21.0	−62 34	5.14	B5	Chile Sta. *LOB* **9**, 37, 1916. Range 30 km. pr.
3265	4 Dra	25.7	69 45	5.25	Ma	Lick, *ASP* **34**, 169, 1922. Range 7 km.
3272	η Crv	26.9	−15 39	4.42	F0	Albrecht, *LOB* **5**, 175, 1910. Two spectra. Rel. vel. 42 km.
3281	κ Dra	29.2	70 20	3.88	B5p	Baker, *Det O* **3**, 29, 1920. Orbit.
3283	23 Com	29.9	23 11	4.78	A0	Yerkes, *ApJ* **32**, 304, 1910. Two spectra.
3284	24 Com	30.1	18 56	6.72	A3	Adams, *ASP* **27**, 132, 1915. Two spectra. Rel. vel. 127 km.
3287	6 Dra	30.5	70 34	5.18	K0	Lick, *ASP* **34**, 169, 1922. Range 12 km.
3299	....	34.1	21 37	5.51	K0	Young, *DAO* **1**, 287, 1921. Range 12 km.
3300	l Cen	34.5	−39 26	4.79	B8p	Chile Sta. *LOB* **7**, 97, 1913. Range 20 km. 10 fr. lines.
3306	....	36.5	10 58	6.33	A5	Plaskett, *DAO* **1**, 287, 1921. Range 45 km. pr.
....	HD 110533	37.8	84 12	7.25	G0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Two spectra. Rel. vel. 155 km. F7.
3320	β Mus	40.1	−67 34	3.26	B3	Chile Sta. *ASP* **34**, 168, 1922. Range 66 km.
3323	32 Vir	40.7	8 13	5.24	A5	Adams, *ASP* **26**, 261, 1914. Two spectra. Orbit.
3328	β Cru	41.9	−59 9	1.50	B1	Wright, *LOB* **5**, 177, 1910. Range 19 km.
3354	32 Cam	48.3	83 58	5.81	A0	Plaskett, *DAO* **1**, 163, 1920. Two spectra. Rel. vel. 205 km. gd.
3360	41 Vir	48.8	12 58	6.34	A3	Bottlinger, *AN* **198**, 154, 1914.
3363	ϵ U Ma	49.6	56 30	1.68	A0p	Ludendorff, *AN* **180**, 273, 1909. Orbit.
3370	α^1 C Vn ftr.	51.4	38 51	5.39	A0p	Harper, *RASC* **13**, 237, 1919. Range 17 km.
3371	α^2, C Vn btr.	51.4	38 52	2.90	A0p	Belopolsky, *AN* **196**, 1, 1913. Orbit.
3377	δ Mus	55.4	−71 1	3.63	K2	Chile Sta. *ASP* **34**, 168, 1922. Range 12 km.
3393	ξ^2 Cen	13 1.1	−49 22	4.40	B3	Moore, *LOB* **6**, 56, 1910. Two spectra. Orbit.
3409	θ Vir	4.8	− 5 0	4.44	A0	Mitchell, *ApJ* **30**, 241, 1909. Per. about 4 mos. H and K give different vel.
....	RS C Vn	6.0	36 28	var	F8	Joy, *ASP* **34**, 221, 1922. Prelim. orbit. Two spectra.
3428	54 Vir	8.1	−18 18	6.27	A0	Adams, *ASP* **26**, 261, 1914. Range 117 km.
3462	64 Vir	17.1	5 41	5.87	A0	Henroteau, *DO* **5**, 71, 1921. Range 26 km. (2 plates). gd.
3474	ζ^1 U Ma btr.	19.9	55 27	2.40	A2p	Pickering, *MN* **50**, 297, 1889. First spectroscopic binary discovered. Two spectra. Orbit.
3475	ζ^2 U Ma ftr.	19.9	55 27	3.96	A2	Frost, Lee, *AN* **177**, 171, 1908. Range 27 km. Independently suspected by Ludendorff, *AN* **177**, 9, 1908. Range 10 km.
3476	α Vir	19.9	−10 38	1.21	B2	Vogel, *AN* **125**, 305, 1890. Two spectra. Orbit.
....	W Vir	20.9	− 2 52	var	cG0 pec	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 69 km. Cepheid var. Per. $17^{d}2711$.
3480	g U Ma	21.2	55 31	4.02	A5	Frost, *AN*, **177**, 172, 1908. Two spectra. Exceedingly short period.
3485	....	23.2	− 0 19	7.53	G5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 46 km. G2.

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
....	SS Hya	13^{h} $25^{m}.0$	−23° 8′	var	A0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. B9. Algol var. Two spectra. Rel. vel. 215 km. Per. $8^{d}.20$.
3506	o Vir	29.1	4 10	4.93	A2p	Mitchell, *ApJ* **30**, 241, 1909.
....	RV U Ma	29.4	54 30	var	F0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 61 km.
3511	....	30.3	37 42	4.96	F0	Wright, Miss Allen, *LOB* **5**, 175, 1910. Orbit.
3512	24 C Vn	30.4	49 32	4.63	A3	Lee, Arbogast, *ApJ* **39**, 40, 1914. Two spectra. pr.
3540	....	38.7	− 5 0	6.47	A0	Mt. Wilson, *Sci* **37**, 643, 1913. Range 105 km.
3546	85 Vir	40.2	−15 16	6.15	A0	Mt. Wilson, *ApJ* **35**, 176, 1912. Range 104 km. pr.
3547	M Cen	40.3	−50 56	4.68	K0	Lick, *LOB* **6**, 151, 1911. Range 13 km.
3555	3 Boo	42.1	26 12	5.91	F5	Young, *DAO* **1**, 163, 1920. Two spectra. Rel. vel. 73 km. gd.
3564	ν Cen	43.5	−41 11	3.53	B2	Palmer, *LOB* **4**, 97, 1906. Orbit.
3566	η U Ma	43.6	49 49	1.91	B3	Mellor, *Det O* **3**, 72, 1917. Range 38 km. pr.
3586	h Cen	47.5	−31 26	4.76	B5	Paddock, *LOB* **6**, 56, 1910. Orbit.
3593	ζ Cen	49.3	−46 48	3.06	B2p	Mrs. Fleming, *Director's Report HCO* 1899. Two spectra, components of unequal brightness.
3596	η Boo	49.9	18 54	2.80	G0	Moore, *LOB* **3**, 85, 1905. Orbit.
3610	υ^2 Cen	55.5	−45 7	4.39	F5	Wright, *LOB* **4**, 97, 1906. Range 13 km.
3613	11 Boo	56.6	27 52	6.12	A3	Young, *DAO* **1**, 287, 1921. Range 29 km. pr.
3615	β Cen	56.8	−59 53	0.86	B1	Chile Sta. *LOB* **8**, 126, 1914. Range 50 km. pr.
3626	α Dra	14 1.7	64 51	3.64	A0p	Campbell, Curtis, *LOB* **2**, 126, 1903. Orbit.
....	W C Vn	2.2	38 18	var	F0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 10 km.
3633	η Aps	5.7	−80 32	4.97	A2p	Mrs. Moore, *LOB* **6**, 151, 1911. Two spectra. Rel. vel. 115 km.
3635	d Boo	5.8	25 34	4.82	F5	Wright, *ApJ* **12**, 255, 1900. Two spectra. Orbit.
3639	....	7.2	2 53	4.90	A0p	Baker, *AO* **1**, 121, 1909.
3644	....	8.5	− 0 22	5.81	F5	Miss Brayton, *ApJ* **54**, 226, 1921. Orbit.
3649	4 U Mi	9.2	78 1	5.00	K0	Young, *LOB* **6**, 57, 1910. Range 11 km.
3652	κ Boo ftr.	9.9	52 15	6.61	A5	Young, *DAO* **1**, 163, 1920. Range 10 km.
3654	κ Boo btr.	9.9	52 15	4.60	A5	Yerkes, *ApJ* **39**, 273, 1914.
3667	21 Boo	12.6	51 50	4.78	A5	Lee, *ApJ* **39**, 46, 1914. Range 19 km. pr.
3672	λ Vir	13.7	−12 55	4.60	A2	Albrecht, *LOB* **6**, 146, 1911. Two spectra. Rel. vel. 52 km.
3673	A Boo	13.8	35 58	4.83	K0	Moore, *LOB* **4**, 162, 1907. Orbit.
3674	....	13.8	51 46	6.09	A0	Young, *DAO* **1**, 163, 1920. Range 27 km. fr.
3682	....	15.5	−58 0	4.89	G0	Mrs. Moore, *LOB* **6**, 151, 1911. Range 7 km.
3692	Σ 1835 ftr.	18.5	8 54	6.64	A0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. F0. A close rapid vis. bin. β 1111, per. approximately 40 yrs. Per. of spectroscopic change too short to be accounted for by movement in vis. orbit.
3697	....	19.2	6 16	5.08	A^3	Jordan, *AO* **1**, 121, 1909.
3700	τ^2 Lup	19.8	−44 56	4.49	F5	Lunt, manuscript. Approx. orbit.
3712	....	23.7	−49 4	5.52	A2	Curtis, *LOB* **5**, 140, 1909. Two spectra. Rel. vel. 170 km.
3724	η Cen	29.2	−41 43	2.65	B3p	Wright, *LOB* **5**, 177, 1910. Range 17 km. Composite spectrum.
....	RS Boo	29.3	32 12	var	F2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 75 km.
3735	α Cen	32.8	−60 25	0.33 1.70	G0 K5	Wright, *LOB* **3**, 3, 1904. Wright finds for epoch 1904.7 difference of radial velocities of two components 5.34 km. Using Roberts's elements $P=81^{y}.185$, $e=0.529$, and $m_2/m_1=49/51$ he deduced $\pi=0''.73$, $a=3.64\times10^9$ km., $m_1+m_2=2.2\odot$, $m_1=1.12$, $\odot$; $m_2=1.08\odot$; $Vo-22.18$ km. See also Lunt, *ApJ* **48**, 182, 1918.
3744	33 Boo	35.1	44 50	5.39	A0	Lee, *ApJ* **39**, 41, 1914. Range 36 km.
3745	α Lup	35.2	−46 58	2.89	B2	Wright, *LOB* **5**, 177, 1910. Range 17 km.
....	HD 129132	35.8	22 24	6.17	F5	Christie, *RASC* **18**, 166, 1924. Range 50 km.
3758	μ Vir	37.8	− 5 13	3.95	F5	Burns, *LOB* **6**, 146, 1911. Range 19 km.
3787	α Lib	45.3	−15 38	2.90	A3	Slipher, *Low OB* **1**, 57, 1904. Range 80 km. Two spectra suspected.
3793	39 Boo ftr.	46.3	49 8	6.8	F5	H. Plaskett, *DAO* **1**, 287, 1921. Two spectra. Orbit.
3815	β Lup	52.0	−42 44	2.81	B2p	Mrs. Fleming, *HCO Circ.*, 21, 1898. Two spectra.
3818	κ Cen	52.6	−41 42	3.35	B3	Curtis, Paddock, *LOB* **5**, 178, 1910. Range 13 km.
3825	δ Lib	55.6	− 8 7	var	A0	Adams, *ApJ* **15**, 214, 1902. Algol var. Orbit.
3827	....	56.0	66 20	4.86	Mb	Young, Burns, *LOB* **6**, 146, 1911. Range 14 km. Hnatek, *AN* **214**, 277, 1921. Two spectra. Rel. vel. 109 km. Orbit.
3846	i Boo ftr	15 0.5	48 3	6.2	G2p	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Two spectra. Rel. vel. 290 km. difficult. Struve, *ApJ* **60**, 1924. Range 46. Two spectra suspected.

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
3865	e Lup	15^h 6^m1	−44° 7′	4.92	B3	Curtis, *LOB* **5**, 140, 1909. Range 36 km.
3866	ι Lib	6.5	−19 25	4.66	A0p	Lick, *LOB* **6**, 146, 1911. Two spectra.
……..	R Tr A	10.8	−66 8	var	F5–G5	Paddock, *LOB* **9**, 68, 1917. Cepheid var. Orbit.
3890	β Lib	11.6	− 9 1	2.74	B8	Lee, *ApJ* **39**, 41, 1914. Range 53 km. Mellor, *Det O* **3**, 73, 1917, finds range 16 km. Per. $=80^d$.
……..	U Cr B	14.1	32 1	var	B8	Plaskett, *DAO* **1**, 187, 1920. Algol var. Orbit.
3905	ε Lup	15.9	−44 20	3.74	B3	Paddock, *LOB* **6**, 151, 1911. Two spectra. Rel. vel. 127 km.
3909	………………………	16.3	50 35	7.36	A0	Harper, *DAO* **1**, 163, 1920. Range 42 km. fr.
3915	50 Boo	17.8	33 17	5.36	B9	Mt. Wilson, *ApJ* **35**, 176, 1912. Range 57 km. pr.
3919	ε Lib	18.8	− 9 58	5.08	F0	Campbell, *ApJ* **10**, 178, 1900. Range 28 km.
3923	η Cr B	19.1	30 39	5.58	G0	Yerkes, *ApJ* **32**, 304, 1910. Brighter component of visual double.
3928	γ U Mi	20.9	72 11	3.14	A2	Struve, *PA* **31**, 90, 1923. Orbit.
3940	β Cr B	23.7	29 27	3.72	F0p	Moore, *LOB* **4**, 162, 1907. Orbit.
……..	HD 138213	25.6	47 35	5.96	A0	Christie, *RASC* **18**, 167, 1924. Range 34 km.
3944	35 Lib	27.3	−16 31	5.59	B3	Mt. Wilson, *ApJ* **35**, 176, 1912. Range 53 km. pr. Possibly composite spectrum.
3951	36 Lib	28.6	−27 43	5.19	K0	Chile Sta. *ASP* **34**, 169, 1922. Range 10 km.
3954	d Lup	29.0	−44 37	4.84	B3	Paddock, *LOB* **6**, 56, 1910. Range 20 km. fr.
3960	δ Ser	30.0	10 53	4.23	F0	Wilson, *LOB* **6**, 146, 1911. Range 21 km. pr. Btr. of vis. double.
3961	α Cr B	30.5	27 3	2.31	A0	Hartmann, *AN* **163**, 31, 1903. Eclipsing var. Orbit.
3968	16 Ser	31.7	16 21	5.40	K0	Lick, *ASP* **36**, 145, 1924. Range 7 km.
……..	TW Dra	32.4	64 14	var	A5	Plaskett, *RASC* **14**, 1, 1920. B9. Orbit.
……..	RW Cr B	35.2	29 57	var	F8	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 118 km. Algol var. probably. Per 0^d726. A8.
3990	κ Lib	36.2	−19 21	4.96	K5	Olivier, *LOB* **6**, 146, 1911. Range 8 km.
3991	ψ^2 Lup	36.3	−34 23	4.82	B5	Paddock, *LOB* **6**, 151, 1911. Two spectra. Rel. vel. 137 km.
3993	χ Ser	37.1	13 10	5.26	A0p	Mt. Wilson, *ApJ* **35**, 176, 1912. Range 40 km. gd.
3994	ι Ser	37.1	20 0	4.49	A2	Yerkes, *ApJ* **32**, 305, 1910. Two spectra. Vis. double.
3998	γ Cr B	38.5	26 37	3.93	A0	Yerkes, *ApJ* **32**, 305, 1910. Two spectra. Btr. of vis. double.
4005	26 Ser	40.2	17 35	5.89	A0	Young, *DAO* **1**, 287, 1921. Range 55 km. K fr. Other lines pr.
4008	A^2 Ser	40.9	− 1 29	5.37	B8	Jordan, *AO* **1**, 121, 1909. Orbit.
4018	χ Lup	44.6	−33 19	4.11	B9	Paddock, *LOB* **6**, 4, 1910. Two spectra.
4033	λ Lib	47.5	−19 52	5.06	B3	Lick, *ASP* **36**, 145, 1924. Range 72 km. pr.
4035	ζ U Mi	47.6	78 6	4.34	A2	Hnatek, *AN* **214**, 278, 1921. Range 111 km. (2 plates.)
4056	4 Her	52.1	42 51	5.61	B8	Plaskett, *DAO* **1**, 287, 1921. Range 32 km. pr.
……..	S Tr A	52.2	−63 30	var	G5	Paddock, *LOB* **9**, 68, 1917. Cepheid var. Per 6^d3231.
4062	π Sco	52.8	−25 50	3.00	B2	Miss Cannon, *HCO Director's Rep* 1899. Two spectra. Per. 1^d57.
4066	δ Sco	54.4	−22 20	2.54	B0	Frost, Lee, *ApJ* **30**, 65, 1909. Two spectra. Miss Maury had suspected binary character. *HCO* **28**, 94 and 176, 1897–1901.
4067	………………………	54.7	−16 14	5.53	F8	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 25 km. F6.
4072	………………………	55.4	55 2	4.96	A5	Yerkes, *ApJ* **39**, 273, 1914.
4080	ι Cr B	57.4	30 8	4.91	A0	Baker, *AO* **1**, 121, 1909.
4081	π Ser	58.0	23 5	4.8	A2	Yerkes, *ApJ* **32**, 306, 1910. Two spectra.
4086	β Sco	59.6	−19 32	2.90	B1	Slipher, *Low OB* **1**, 4, 1903. Orbit. Adams, *ApJ* **18**, 69, 1903. Two spectra.
4090	θ Dra	16 0.0	58 50	4.11	F8	Campbell, *ApJ* **9**, 311, 1899. Orbit.
……..	HD 144426	0.8	8 22	6.14	A2	J. W. Campbell, *DAO* **1**, 287, 1921. Orbit.
……..	HD 144515	1.2	10 57	8.5	G5	Adams, Joy, *ASP* **31**, 42, 1919. K0. Orbit.
4097	11 Sco	2.1	−12 29	5.64	A0	Mt. Wilson, *ApJ* **35**, 176, 1912. Range 44 km. pr.
4098	45 Ser	2.9	10 10	5.63	A5	Young, *RASC* **12**, 461, 1918. Range 29 km. fr.
4104	8 Her	4.3	17 28	6.07	A0	Young, *RASC* **12**, 461, 1918. Range 64 km. pr.
4106	………………………	4.6	− 3 12	5.41	K0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 22 km. K5.
4117	ν Sco	6.2	−19 12	4.29	B3	Slipher, *2^d Cat. Spec. Bin.* Range 65 km. Btr. of vis. double.
4121	………………………	6.8	77 4	5.60	A0	Young, *DAO* **1**, 163, 1920. Range 28 km. fr.
4123	………………………	7.1	58 12	6.31	A0	Plaskett, *RASC* **12**, 461, 1918. Range 38 km. pr.
4129	………………………	8.1	36 41	5.68	K5	Young, *DAO* **1**, 287, 1921. Range 26 km.
……..	S Nor	10.6	−57 39	var	G0p	Paddock, *LOB* **9**, 68, 1917. Cepheid var., Per. 9^d7525.
4138	σ Cr B btr.	10.9	34 7	5.76	G0	Adams, *ASP* **28**, 80, 1916. Two spectra. Btr. of vis. double.

TABLE I—Continued.

Boss	Star	R.A., 1900		Decl.	Mag.	Class	Discoverer and Reference
4149	....	16^h	13^{m}2	−30° 40′	5.42	F2	Chile Sta. *ASP* **34**, 169, 1922. Range 24 km.
4158	σ Sco		15.1	−25 21	3.08	B1	Slipher, *Low OB* **1**, 57, 1904. Orbit.
4166	ζ Tr A		17.7	−69 52	4.93	G0	Curtis, *LOB* **5**, 140, 1909. Orbit.
4168	γ Aps		18.1	−78 40	3.90	K0	Curtis, *LOB* **5**, 177, 1909. Range 6 km.
4174	ι Tr A		18.7	−63 50	5.30	F0	Chile Sta. *LOB* **8**, 74, 1914. Orbit.
4177	o Her		19.3	7 11	5.72	A0	Young, *DAO* **1**, 287, 1921. Range 28 km. fr.
4180	ε Nor		19.8	−47 20	4.80	B5	Chile Sta. *LOB* **9**, 38, 1916. Two spectra. Rel. vel. 224 km.
4181	η U Mi		20.4	75 59	5.04	F0	Hnatek, *ApJ* **52**, 198, 1920. Range 57 km.
4183	χ Oph		21.2	−18 14	4.85	B3p	Campbell, Albrecht, *LOB* **5**, 175, 1910. Range 33 km. Double bright Hγ. Confirmed Mt. Wilson, *ApJ* **35**, 180, 1912.
4193	α Sco		23.3	−26 13	1.22	Map	Wright, *LOB* **4**, 98, 1906. Orbit
4200	N Sco		24.8	−34 29	4.33	B3	Paddock, *LOB* **6**, 152, 1911. Range 25 km.
4203	λ Oph		25.9	2 12	3.85	A0	Frost, *AN* **177**, 174, 1908. Vis. bin. Per. 203^{y}9. Doberk, *AN* **89**, 215, 1877.
4204	β Her		25.9	21 42	2.81	K0	Campbell, *ApJ* **11**, 140, 1899. Orbit.
....	VX Her		26.2	18 36	var	A3	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 31 km.
4213	A Dra		28.2	68 59	4.98	B8p	Hnatek, *AN* **210**, 246, 1919. Two spectra. Rel. vel. 112 km.
4217	....		29.6	30 43	6.66	F0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 98 km.
....	HD 149632		30.9	17 15	6.27	A0	Young, *DAO* **1**, 163, 1920. Two spectra. Orbit.
....	RW Dra		33.7	58 3	var	A5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 30 km.
4246	ζ Her		37.5	31 47	3.00	G0	Wright, *LOB* **1**, 159, 1902. Vis. bin. Per. 34^y. Radial vel. shows that $i=-50°$.
4247	39 Her		37.6	27 7	5.91	F2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Two spectra. Rel. vel. 190 km. Per. 2^d±. F2p.
4260	16 Oph		40.4	1 12	5.99	B9	H. Plaskett, *DAO* **1**, 287, 1921. Range 18 km. gd.
4266	19 Oph		42.1	2 15	6.04	A2	H. Plaskett, *DAO* **1**, 287, 1921. Two spectra. Rel. vel. 70 km. pr.
4269	l Her		42.8	5 26	5.28	A0p	Lick, *ASP* **30**, 353, 1918. Range 9 km. gd.
4277	μ^1 Sco		45.1	−37 53	3.09	B3p	Bailey, *HCO Circ. No.* **11**, 1896. Two spectra. Orbit.
4302	ι Oph		49.3	10 20	4.29	B8	Albrecht, *LOB* **6**, 57, 1910. Two spectra. Rel. vel. 86 km. pr.
....	RV Sco		51.8	−33 27	var	F5–G5	Paddock, *LOB* **9**, 68, 1917. Cepheid var. Per. 6^{d}0622.
....	Gr 2398		52.2	75 33	7.6	F1	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 29 km.
4322	h Dra		55.5	65 17	4.82	F5	Campbell, *ApJ* **10**, 178, 1899. Orbit.
4327	ε U Mi		56.2	82 12	4.40	G5	Campbell, *ApJ* **10**, 179, 1899. Orbit.
4328	ε Her		56.5	31 4	3.92	A0	Campbell, Curtis, *LOB* **2**, 126, 1903. Orbit. Adams, *ApJ* **18**, 69, 1903.
....	HD 154400	17	0.3	34 56	6.01	A3	Christie, *RASC* **18**, 167, 1924. Range 116 km.
4351	....		2.2	48 56	6.32	K0	Young, *DAO* **1**, 287, 1921. Range 17 km.
4353	....		3.1	− 0 57	6.02	A0	Mt. Wilson, *ApJ* **35**, 177, 1912. Range 31 km. fr.
4357	....		4.4	24 37	6.82	A0	Harper, *DAO* **1**, 287, 1921. Range 49 km. pr.
....	HD 155375		6.1	12 35	6.46	A0	Young, *DAO* **1**, 163, 1920. Orbit.
4364	....		6.3	40 54	5.12	K0	Lick, *ASP* **36**, 145, 1924. Range 8 km.
4374	α Her ftr.		10.1	14 30	5.39	F9	Sanford, *ApJ* **53**, 201, 1921. Orbit.
4376	δ Her		10.9	24 57	3.16	A2	Harper, *RASC* **2**, 107, 1908.
....	U Oph		11.4	1 19	var	B8	Plaskett, *DAO* **1**, 137, 1919. Two spectra. Algol var. Orbit.
4388	u Her		13.6	33 12	var	B3	Frost, Adams, *ApJ* **17**, 381, 1903. Two spectra. Orbit.
4391	e Her		14.2	37 24	4.80	A2	Lee, *ApJ* **60**, 1924. Range 35 km.
....	TX Her		15.4	42 0	var	A5	Plaskett, *DAO* **1**, 207, 1920. Two spectra. Algol var. Orbit.
4399	θ Oph		15.9	−24 54	3.37	B3	Henroteau, *DO* **8**, 3, 1922. Per. 0^{d}28620.
4401	....		16.1	25 37	5.32	A2	Young, *DAO* **1**, 287, 1921. Range 15 km. gd. Lick, *ASP* **34**, 162, 1922. Range 12 km.
4402	70 Her		16.8	24 36	5.12	A0	Mt. Wilson, *ApJ* **35**, 177, 1912. Range 23 km. fr.
4411	....		18.4	40 4	5.72	F8	Plaskett, *DAO* **1**, 163, 1920. Range 24 km. gd.
4423	....		21.3	− 5 0	4.61	F0	Burns, *LOB* **4**, 96, 1906. Two spectra. Orbit.
4429	υ Sco		24.0	−37 13	2.80	B3	Wright, *LOB* **5**, 177, 1910. Range 40 km.
4431	α Ara		24.1	−49 48	2.97	B3p	Paddock, *LOB* **6**, 152, 1911. Range 29 km. Double brt. H.
4432	....		24.4	60 8	5.66	A2	Hnatek, *AN* **214**, 278, 1921. Range 30 km. pr.
4437	....		26.4	2 48	5.59	G0p	Harper, *DAO* **1**, 287, 1921. Range 21 km.
4438	λ Her		26.7	26 11	4.48	K0	Bonn, *AN* **198**, 433, 1914. Range 10 km.
4439	λ Sco		26.8	−37 2	1.71	B2	Slipher, *Low OB* **1**, 23, 1903. Per. about 5^{d}6.
....	HD 159082		27.6	12 0	6.18	B9	J. W. Campbell, *DAO* **2**, 159, 1922. Orbit.

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
4450	Q Sco	17^h 29^{m}7	−38° 34′	4.34	K0	Chile Sta. *LOB* **7**, 97, 1912. Range 7 km.
4459	α Oph	30.3	12 38	2.14	A5	Frost, *AN* **177**, 174, 1908. Lee, *ApJ* **39**, 47, 1914. Two spectra. Rel. vel. 200 km.
4460	ν² Dra	30.3	55 14	4.95	A5	Albrecht, *LOB* **5**, 62, 1908. Range 19 km. pr.
4462	ξ Ser	31.9	−15 20	3.64	A5	Curtis, *LOB* **3**, 85, 1905. Orbit.
4464	f Dra	32.4	68 12	5.21	K0	Miss Hobe, *LOB* **6**, 58, 1910. Range 5 km.
....	RT Ser	34.3	−11 53	var	cA8	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 81 km. Barnard's "Life-time var." Change shown is of long per. and continually decreasing vel.
4474	κ Sco	35.6	−38 59	2.51	B2	Chile Sta. *LOB* **9**, 38, 1916. Range 70 km. pr.
4479	ι Her	36.6	46 4	3.79	B3	Henroteau, *DO* **5**, 346, 1921. From comparison with Yerkes results, 1901 and 1902, and *DO*, 1920, range is 12 km.
....	HD 160861	37.2	68 27	8.1	F5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 88 km. F2.
4483	ω Dra	37.5	68 48	4.87	F5	Campbell, *ApJ* **10**, 179, 1899. Orbit.
4493	X Sgr	41.3	−27 48	var	F8	Slipher, *Low OB* **1**, 57, 1904. Cepheid var. Type var. F1–G5. Shapley, *ApJ* **44**, 273, 1916. Orbit.
4499	....	42.7	17 44	5.58	A0	Harper, *DAO* **1**, 163, 1920. Range 28 km. gd.
4500	γ Oph	42.9	2 45	3.74	A0	Yerkes, *ApJ* **32**, 306, 1910. Two spectra.
4504	ψ² Dra	43.7	72 12	6.07	F5	Hnatek, *ApJ* **52**, 198, 1920. Range 28 km.
4507	....	44.4	47 39	6.34	A0	Harper, *DAO* **1**, 163, 1920. Orbit.
....	Y Oph	47.3	− 6 7	var	G0p	Albrecht, *LOB* **4**, 68, 1906. Cepheid var. Type var. F5–G3, Shapley, *ApJ* **44**, 274, 1916. Orbit.
4516	....	48.4	6 7	5.82	F5	H. Plaskett, *DAO* **1**, 287, 1921. Range 12 km.
4531	ξ Dra	51.8	56 53	3.90	K0	Burns, *LOB* **6**, 147, 1911. Range 5 km.
....	Z Her	53.6	15 9	var	F5p	Frost, *ApJ* **22**, 214, 1905. Algol var. Two spectra. Orbit.
4544	ζ Ser	55.2	− 3 41	4.60	F0	Merrill, *LOB* **7**, 116, 1913. Range 15 km. pr.
....	HD 164492	56.3	−23 1	6.91	Oe5	*DAO*, 1924. Range 17 km.
4552	68 Oph	56.7	1 18	4.44	A2	Frost, Lee, *Sci* **32**, 876, 1910.
4559	τ Oph	57.6	− 8 11	5.34	F0	Wilson, *LOB* **6**, 147, 1911. Range 9 km. Btr. of vis. double.
4560	9 Sgr	57.7	−24 22	5.86	Oe5	*DAO*, 1924. Range 35 km.
4562	96 Her	58.1	20 50	5.09	B3	Mitchell, *Sci* **34**, 529, 1911. Four components. Per. 50^{d}2.
4563	....	58.3	22 55	6.12	B8	H. Plaskett, *DAO* **1**, 287, 1921. Range 27 km. pr. Nearer B3.
4564	W Sgr	58.6	−29 35	var	F8p	Curtiss, *LOB* **3**, 31, 1904. Cepheid var. Type A8–G2, Shapley. Orbit.
4567	....	59.0	−24 24	6.79	Oe5	*DAO*, 1924. Range 44 km.
4568	γ Sgr	59.4	−30 26	3.07	K0	Wright, *LOB* **6**, 153, 1911. Range 6 km.
4571	70 Oph	18 0.4	2 31	4.07	K0	Campbell, *LOB* **5**, 63, 1908. Radial velocities show that the inclination of vis. orbit plane is −58°5, and approximate radial velocity of center of mass −7.4 km. Pavel's period of the visual binary is 87^{y}710. *AN* **212**, 347, 1921.
4573	....	0.7	− 8 20	5.79	B8	Adams, Joy, *ASP* **29**, 259, 1917.
....	HD 165645	1.9	41 56	6.42	F0	Young, *RASC* **13**, 60, 1919. Range 25 km. pr.
....	HD 165670	2.1	8 52	7.7	F5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 39 km. F7.
4581	72 Oph	2.6	9 33	3.73	A3	Barrett, *ApJ* **30**, 65, 1909. Two spectra.
....	W Ser	4.1	−15 34	var	cF9	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 42 km. Per. 14^{d}13.
4590	102 Her	4.5	20 48	4.32	B3	Albrecht, *LOB* **6**, 147, 1911. Range 6 km.
4602	40 Dra	7.5	79 59	6.18	F5	Plaskett, *RASC* **12**, 461, 1918. Two spectra. .Orbit.
4604	μ Sgr	7.8	−21 5	4.01	B8p	Frost, Adams, *ApJ* **19**, 351, 1904. Orbit.
....	HD 166988	8.1	33 26	5.85	A2	Plaskett, *RASC* **13**, 60, 1919. Range 53 km. fr.
4612	....	9.2	−20 45	5.42	B0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 68 km.
4613	16 Sgr	9.3	−20 25	6.02	B1	Mt. Wilson, *Sci* **37**, 643, 1913. Range 86 km. Two spectra.
4614	....	9.7	38 45	5.88	A0	Young, *RASC* **13**, 60, 1919. Range 40 km. fr.
....	RS Sgr	11.0	−34 8	var	B5	Paddock, *LOB* **9**, 39, 1916. Algol var. Per. 2^{d}415702. Range 140 km.
....	WZ Sgr	11.1	−19 7	var	G5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 84 km. Cepheid var. Per. 21^{d}7. cG0.
....	HD 167771	11.6	−18 30	6.37	Oe5	*DAO*, 1924. Range 120 km.
4622	....	12.9	56 33	6.41	F0	Harper, *DAO* **1**, 163, 1920. Two spectra. Orbit.
4625	ξ Pav	14.0	−61 32	4.25	K2	Mrs. Moore, *LOB* **6**, 152, 1911. Range 36 km.
4629	105 Her	15.1	24 24	5.49	K5	Lick, *ASP* **34**, 169, 1922. Range 12 km.
4632	Y Sgr	15.5	−18 54	var	F5p	Curtiss, *LOB* **3**, 40, 1904. Cepheid var. Type F4–G4. Orbit.

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
4644	t Her	18^h 17^m1	28° 49′	5.05	A5	Plaskett, *RASC* **13**, 60, 1919. Range 21 km. fr.
4643	108 Her	17.1	29 48	5.54	A2	Mt. Wilson, *ApJ* **35**, 177, 1912. Two spectra. Orbit.
4647	....	17.6	51 18	6.25	K2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 42 km. K0.
4650	ζ Sct	18.2	− 8 59	4.83	G5	Burns, *LOB* **6**, 147, 1911. Range 10 km.
4655	21 Sgr	19.4	−20 35	4.96	G5	Young, *LOB* **6**, 147, 1911. Range 6 km.
4660	....	20.8	7 59	5.69	G0 A3	Adams, *ASP* **26**, 261, 1914. Range 42 km.
4661	μ Lyr	20.9	39 27	5.04	A2	Young, *RASC* **12**, 461, 1918. Range 23 km. fr.
4667	d Ser	22.1	0 8	5.33	A0	Frost, Lee, *ApJ* **30**, 66, 1909. Composite spectrum. Two spectra. Lick.
4669	....	22.1	29 46	5.71	A2	Adams, Joy, *ASP* **29**, 259, 1917. Orbit. Young *RASC* **12**, 461, 1918.
4670	φ Dra	22.2	71 17	4.24	A0p	Frost, Lee, *ApJ* **30**, 66, 1909. Two spectra. Btr. of vis. double.
4671	b Dra	22.5	58 45	4.85	A2	Monk, *ApJ* **60**, 1924. Range 223 km. Two spectra. Rel. vel. =150 km.
....	HD 170111	22.7	26 23	6.36	B3	Christie, *RASC* **18**, 167, 1924. Range 73 km.
4672	χ Dra	22.9	72 41	3.69	F8	Wright, *ApJ* **8** 292, 1898. Orbit.
4677	δ^1 Tel	24.4	−45 59	5.05	B8	Curtis, *LOB* **5**, 140, 1909. Range 99 km. gd.
4678	....	24.5	− 2 3	5.44	K0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 25 km. G9.
4680	δ^2 Tel	24.6	−45 50	5.33	B5	Curtis, *LOB* **5**, 140, 1909. Range 62 km. gd.
....	RX Her	26.0	12 30	var	A0	Frost, *ApJ* **22**, 215, 1905. Two spectra. Algol var. Orbit.
....	U Sgr	26.0	−19 12	var	F8	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 12 km. Cepheid var. Per. 6^d74467. cG0.
4706	45 Dra	30.8	18 7	5.73	A0	Plaskett, *RASC* **12**, 461, 1918. Range 57 km. fr. A2.
4713	....	31.8	6 36	5.41	F2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 31 km. F0.
4730	....	36.7	62 26	6.0	A0	Hnatek, *ApJ* **52**, 198, 1920. Range 7 km. (2 plates.)
4731	δ Sct	36.8	− 9 9	4.74	F0	Wright, *ApJ* **12**, 256, 1900.
4739	φ Sgr	39.4	−27 6	3.30	B8	Frost, *Sci* **28**, 853, 1908.
....	RZ Lyr	39.9	32 42	var	A2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 120 km.
4744	Σ 2375	40.6	5 24	5.72	A0	H. Plaskett, *DAO* **1**, 287, 1921. Range 99 km.
4745	46 Dra	40.7	55 26	5.08	A0	Harper *DAO* **1**, 287, 1921. Two spectra. Rel. vel. 74 km. gd.
....	RZ Oph	40.9	7 7	var	cGo	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 24 km. Algol var.
4747	ε (A) Lyr btr.	41.0	39 34	5.06	A3	Frost, *AN* **177**, 174, 1908.
4752	ζ^1 Lyr	41.3	37 30	4.29	A3	Curtis, *LOB* **3**, 85, 1905. Orbit.
4756	β Sct	41.9	− 4 51	4.47	G0	Wright, *ApJ* **12**, 255, 1900. Orbit.
4759	R Sct	42.2	− 5 49	var	K0p	Joy, *ASP* **34**, 349, 1902. Range 25 km. Curtiss, *PA* **32**, 221, 1924. Range 10 km. Spectrum changes G5 – K0. Per. =65–75d.
4761	111 Her	42.6	18 4	4.37	A3	Wright, *LOB* **5**, 63, 1908. Range 38 km.
....	YZ Sgr	43.7	−16 50	var	G5p	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 13 km. Cepheid var. Per. 9^d553. cG1.
4765	....	44.5	52 53	5.76	B5	H. Plaskett, *DAO* **1**, 287, 1921. Range 41 km. B3.
....	205 Dra btr. comp β 971	45.0	49 19	7.18	F5	Adams, Joy, *ASP* **31**, 42, 1919. Two spectra. F2. Orbit.
4776	β Lyr	46.4	33 15	var	B8p	Pickering, *AN* **128**, 40, 1891. Orbit.
4777	....	46.4	33 14	var	B2p	H. Plaskett, *DAO* **1**, 287, 1921. Range 36 km. B8. Ft. var. comp. of β Lyr.
4778	κ Pav	46.6	−67 22	var	F5p	Wright, *LOB* **3**, 3, 1904. Cepheid var. Per. 9^d09155.
4785	ν^2 Sgr	49.1	−22 48	5.04	K0	Moore, *LOB* **7**, 97, 1912. Range 11 km.
4788	50 Dra	49.6	75 19	5.37	A0	Frost, *PA* **22**, 568, 1914. Two spectra. Orbit.
4790	ο Dra	49.7	59 16	4.78	K0	Burns, *LOB* **5**, 175, 1910. Orbit.
4794	δ^1 Lyr	50.2	36 51	5.51	B3	Frost, Adams, *ApJ* **19**, 352, 1904. Orbit.
4796	λ Tel	50.5	−53 4	5.03	B9	Chile Sta. *LOB* **7**, 97, 1912. Range 50 km.
4797	113 Her	50.5	22 31	4.56	G0	Wright, *ApJ* **12**, 256, 1900. Orbit.
4798	62 Ser	50.6	6 29	5.66	G5	H. Plaskett, *DAO* **1**, 287, 1921. Range 14 km.
4799	....	50.7	50 35	4.97	G5	Albrecht, *LOB* **6**, 148, 1911. Range 10 km.
4814	R Lyr	52.3	43 49	var	Mb	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 15 km. *AO* **2**, 125, 1911. Range 11 km.
....	HD 175876	52.3	−20 33	6.73	Oe5	*DAO*, 1924. Range 89 km.
4817	....	53.8	17 14	5.37	F5	Lick, *ASP* **36**, 145, 1924. Range 11 km. gd.
4821	....	54 6	38 8	5.75	B8	Adams, Joy, *ASP* **29**, 259, 1917. Per. 3^d±

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
4823	ε Aql	18^h $55^m.1$	14° 56′	4.21	K0	Bonn, *AN* **198**, 435, 1914.
4824	γ Lyr	55.2	32 33	3.30	A0p	Mitchell, *ApJ* **30**, 240, 1909. Two spectra suspected. Per. 3 or 4 hrs. Curtiss, *RASC* **10**, 426, 1916.
4825	υ Dra	55.6	71 10	4.91	K0	Burns, *LOB* **5**, 175, 1910. Range 10 km.
4837	Σ 2452	56.9	75 39	6.18	A0	H. Plaskett, *DAO* **1**, 287, 1921. Range 33 km.
4838	Σ2452	56.9	75 39	....	A0	H. Plaskett, *DAO* **1**, 287, 1921. Range 26 km. Spectrum identical with Boss 4837.
4844	ρ Tel	58.4	−52 29	5.18	G0	Chile Sta. *LOB* **8**, 75, 1914. Two spectra. Rel. vel. 187 km.
4845	....	58.5	1 40	5.72	A2	Harper, *DAO* **1**, 287, 1921. Two spectra. Rel. vel. 146 km.
....	SZ Aql	59.6	1 9	var	K2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 22 km. Cepheid var. Per. 17^{d}1362. cG1.
4857	τ Sgr	19 0.7	−27 49	3.42	K0	Wright, *LOB* **3**, 3, 1904. Curtis, *LOB* **3**, 85, 1905.
4858	ζ Aql	0.8	13 43	3.02	A0	*Rep. Chief Astronomer, Can*, 248, 1911.
4864	18 Aql	2.3	10 55	5.10	B8	Frost, Adams, *ApJ* **18**, 387, 1903. Orbit.
4867	....	2.7	28 28	5.46	A5	Mt. Wilson, *ApJ* **35**, 177, 1912. Range 36 km. pr. Composite spectrum suspected.
4869	51 Dra	2.7	53 15	5.35	A0	Young, *DAO* **1**, 163, 1920. Range 75 km. pr.
4870	....	3.0	41 16	6.15	B3	Young, *RASC* **12**, 461, 1918. Orbit.
....	TT Aql	3.1	1 8	var	cG2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 33 km. Cepheid var. Per. 13^{d}753.
....	HD 178428	3.5	16 42	5.99	G5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 28 km. G6.
....	HD 178619	4.2	16 42	6.46	F5	Christie, *RASC* **18**, 167, 1924. Range 177 km.
4876	....	4.4	38 46	7.48	A3	Young, *DAO* **1**, 163, 1920. Range 106 km. gd.
4880	....	6.5	−21 49	6.42	K0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 33 km.
4891	ψ Sgr	9.4	−25 26	4.93	F5	Chile Sta. *LOB* **8**, 75, 1914. Two spectra. Rel. vel. 130 km.
4897	η Lyr	10.4	38 58	4.46	B3	Albrecht, *LOB* **5**, 175, 1910. Range 11 km.
4906	1 Vul	11.9	21 13	4.60	B5	Yerkes, *ApJ* **39**, 273, 1914.
....	RS Vul	13.4	22 16	var	B8	Plaskett, *DAO* **1**, 137, 1919. Two spectra. Orbit.
....	U Sge	14.4	19 26	var	B9	Frost, *ApJ* **22**, 214, 1905. Algol var. Orbit.
4923	κ Cyg	14.8	53 11	3.98	K0	Miss Hobe, *LOB* **6**, 148, 1911. Range 7 km.
4926	f Aql	15.2	− 5 36	5.10	G5	Lick, *ASP* **34**, 169, 1922. Range 14 km.
4928	d Aql	15.4	− 1 5	5.46	B9	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 29 km.
4934	υ Sgr	16.0	−16 9	4.58	B8p	Campbell, *ApJ* **10**, 241, 1899. Brt. He lines which Frost finds variable. Orbit.
4936	α Sgr	16.9	−40 48	4.11	B8	Curtis, *LOB* **6**, 148, 1911. Range 36 km.
4940	τ Dra	17.5	73 10	4.63	K0	Albrecht, *LOB* **5**, 175, 1910. Range 6 km.
....	Z Vul	17.5	25 23	var	B3	Plaskett, *DAO* **1**, 249, 1920. Two spectra. Algol var. Orbit.
4947	2 Sge	19.8	16 45	6.03	A0	Mt. Wilson, *ApJ* **35**, 177, 1912. Two spectra. Orbit.
4951	3 Sge	20.3	16 46	6.76	A0	H. Plaskett, *DAO* **1**, 287, 1921. Range 36 km. gd.
4953	δ Aql	20.5	2 55	3.44	F0	Campbell, Curtis, *LOB* **2**, 126, 1903. Range 16 km. pr. β C Ma type, Henroteau, *DO*, **8**, 73, 1923.
....	RR Lyr	22.3	42 36	var	F5	Keiss, *LOB* **7**, 140, 1913. Cluster variable. Orbit.
4971	λ U Mi	22.5	88 59	6.55	Mb	Young, *DAO* **1**, 287, 1921. Range 14 km. gd.
4972	4 Cyg	22.6	36 7	5.15	A0p	Plaskett, *RASC* **13**, 60, 1919. Range 16 km. gd.
....	U Aql	24.0	− 7 15	var	F8p	Albrecht, *ASP* **18**, 142, 1906. Cepheid var. Per. 7^{d}02387. Spect. varies F6–G2. Shapley.
4980	7 Cyg	25.0	52 7	5.66	A0	Young, *DAO* **1**, 163, 1920. Range 22 km. gd.
4981	7 Vul	25.0	20 4	6.39	B3	H. Plaskett, *DAO* **1**, 287, 1921. Range 33 km. pr.
4986	β Cyg btr.	26.7	27.45	3.24	K0	Lick, *ASP* **31**, 38, 1919. Range 4 km. HCO composite.
4992	8 Cyg	28.1	34 14	4.85	B3	Henroteau, *DO* **5**, 351, 1921. Range 26 km. fr. β C Ma type.
....	BD+55°2215	29.2	55 32	6.52	K2 A3	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. G5p.
4997	51 Sgr	30.0	−24 56	5.68	A3p	Curtis, *LOB* **6**, 148, 1911. Range 16 km. gd.
4999	52 Sgr	30.6	−25 6	4.66	B9	Paddock, *LOB* **6**, 152, 1911. Range 18 km.
5000	9 Cyg	30.9	29 14	5.42	F5	Plaskett, *DAO* **1**, 163, 1920. Range 38 km. gd.
5004	ι Aql	31.5	− 1 30	4.28	B5	Merrill, *LOB* **6**, 148, 1911. Range 27 km. β C Ma type, Henroteau, *DO* **5**, 352, 1921.
....	U Vul	32.3	20 7	var	G5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 23 km. Cepheid var. Per. 7^{d}98950. cG0.
5018	σ Aql	34.3	5 10	5.17	B3	Mt. Wilson, *Sci* **37**, 643, 1913. Two spectra. Orbit.
5021	φ Cyg	35.4	29 55	4.79	K0	Campbell, Plummer, *LOB* **5**, 63, 1908. Two spectra. Rel. vel. 54 km.

TABLE I—Continued.

Boss	Star		R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
5026	....	19^{h}	$36^{m}.4$	54° 44′	5.86	F5	Harper, *ApJ* **51**, 187, 1920. Two spectra. Orbit.
5034	70 Pav		37.9	−72 45	5.52	A3	Chile Sta. *LOB* **8**, 126, 1914. Range 36 km. pr.
5042	ψ Aql		39.9	13 4	6.12	B8	Mt. Wilson, *ApJ* **35**, 177, 1912. Range 43 km. gd.
....	SU Cyg		40.8	29 1	var	F2p	Maddrill, *LOB* **4**, 97, 1906. Cepheid var. Type A6–F7, Shapley. Orbit.
....	BD+23°3760		41.2	23 41	7.01	B8	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 50 km.
5052	δ Sge		42.9	18 17	3.78	Ma	Campbell, *LOB* **4**, 96, 1906. Range 14 km.
5060	....		45.0	−40 8	5.39	A0p	Chile Sta. *LOB* **8**, 76, 1914. Range 24 km. gd.
5070	....		47.2	40 21	5.62	B2	Adams, *Sci* **37**, 643, 1913. Orbit.
5071	η Aql		47.4	0 45	var	G0p	Belopolsky, *ApJ* **6**, 393, 1897. Cepheid var. Type A8–G5, Shapley. Orbit.
5073	9 Sge		47.9	18 25	6.29	Oe5	Rufus, *ApJ* **51**, 252, 1920. Range 25 km.
5079	ε Dra		48.5	70 1	3.99	K0	Campbell, *LOB* **5**, 175, 1910. Range 5 km.
5086	13 Vul		49.2	23 49	4.50	A0	Yerkes, *ApJ* **32**, 307, 1910. Complex spectrum.
5095	b Sgr		50.8	−27 26	4.62	K2	Mrs. Moore, *LOB* **6**, 152, 1911. Range 9 km.
5098	S Sge		51.5	16 22	var	G0p	Curtiss, *LOB* **3**, 40, 1904. Cepheid var. Type F4–G3, Shapley. Orbit.
5099	φ Aql		51.5	11 9	5.29	A2	Lick, *ASP* **34**, 169, 1922. Orbit.
5104	A Sgr		52.8	−26 28	4.95	G5	Lick, *LOB* **6**, 58, 1910. Range 13 km.
5108	θ Sgr		53.2	−35 33	4.39	B3	Paddock, *LOB* **6**, 4, 1910. Orbit.
5113	....		53.8	40 6	5.43	B3	Mt. Wilson, *ApJ* **35**, 177, 1912. Range 88 km. pr.
5123	14 Vul		54.9	22 50	5.70	F0	Harper, *DAO* **1**, 287, 1921. Range 57 km. pr.
....	β BC 9818		56.6	10 28	6.89	F2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 84 km. Per. about 2 d. F3.
....	HD 190429N		59.8	35 45	7.2	Oe	*DAO*, 1924. Range 63 km.
....	HD 190429S		59.8	35 45	7.5	Oe	*DAO*, 1924. Range 58 km. O9.
5150	....	20	0.7	31 56	5.69	B0	Adams, Joy, *ASP* **29**, 259, 1917. Range 15 km. K constant vel. gd. B1p. Young, *RASC* **13**, 60, 1919.
....	HD 190864		1.9	35 19	8.2	B	*DAO*, 1924. Range 34 km.
....	HD 190919		2.2	35 24	7.30	B	*DAO*, 1924. Range 33 km.
5160	....		3.1	−10 21	6.17	A0	Adams, Joy, *ASP* **29**, 259, 1917. Two spectra. A1p.
5170	b^2Cyg		5.7	36 33	4.82	B2p	Losh, *DetO* (unpublished). Range 10–15 km. 110 plates.
5171	θ Aql		6.1	− 1 7	3.37	A0	Deslandres, *CR* **136**, 205, 1903. Two spectra. Orbit.
5173	18 Vul		6.4	26 36	5.46	A2	Adams, *ASP* **27**, 132, 1915. Two spectra. Orbit.
....	RW Aql		7.3	15 46	var	F0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 17 km. Cepheid var.
5178	20 Vul		7.8	26 11	5.91	B8	Mt. Wilson, *ApJ* **35**, 178, 1912. Range 22 km. pr. Hβ doubly reversed.
....	R Sge		9.5	16 25	var	G5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 60 km. Cepheid var. Per. $70^{d}.56$. cG1.
5184	68 Dra		9.9	61 47	5.72	F5	Hnatek, *ApJ* **52**, 198, 1920. Range 7 km. (2 plates)
5187	31 Cyg		10.5	46 26	3.95	K0	Campbell, *LOB* **1**, 22, 1901. HCO composite.
5190	....		11.0	25 17	4.82	B3	Lee, *ApJ* **39**, 41, 1914. Two spectra. pr.
5191	33 Cyg		11.1	56 16	4.32	A3	Frost, Lee, *Sci* **32**, 876, 1910.
5192	22 Vul		11.2	23 12	5.38	G5	Lick, *ASP* **34**, 169, 1922. Range 52 km.
5200	32 Cyg		12.4	47 24	4.16	K0	Burns, *LOB* **4**, 96, 1906. Orbit.
5202	α^2 Cap		12.5	−12 51	3.77	G5	Lunt, *ApJ* **48**, 271, 1918.
5210	Σ 266		14.6	40.25	5.82	B2p	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 48 km. Two spectra suspected.
5211	36 Cyg		14.7	36 41	5.52	A0	Mt. Wilson, *ApJ* **35**, 178, 1912. Range 29 km. fr.
5213	35 Cyg		14.8	34 40	5.18	F5p	Lick, *ASP* **34**, 169, 1922.
5216	β Cap		15.4	−15 6	3.25	G0	Campbell, *ApJ* **10**, 241, 1899. Orbit.
5218	Σ 2671		15.9	55 5	5.71	A0	Adams, Joy, *ASP* **29**, 259, 1917.
....	HD 193793		17.1	43 32	6.83	Oe	*DAO*, 1924. Range 50 km.
5223	α Pav		17.7	−57 3	2.12	B3	Wright, Albrecht, *LOB* **4**, 154, 1907. Orbit.
5225	71 Dra		17.9	61 56	5.61	A	Plaskett, *RASC* **13**, 61, 1919. Range 30 km. fr. Hnatek, *ApJ* **52**, 198, 1920. Range 51 km.
5230	....		18.8	45 28	5.87	K0	H. Plaskett, *DAO* **1**, 287, 1921. Range 10 km. gd.
5236	....		20.0	37 9	5.68	B3	Plaskett, *RASC* **12**, 461, 1918. Two spectra. Range 21 km.
5250	....		24.0	56 19	6.21	A0	Young, *RASC* **13**, 61, 1919. Range 33 km. fr.
5270	θ Cep		27.9	62 39	4.28	A5	Campbell, Albrecht, *LOB* **5**, 176, 1910. Range 20 km. pr. Two spectra, but not separable.
5272	ε Del		28.4	10 58	3.98	B5	Lick, *LOB* **6**, 148, 1911. Range 10 km. fr. From comparison of Yerkes, *Publ. YO* **2**, 246, 1904, and Lick velocities.

TABLE I—Continued.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
....	V Vul	20^{h} $32^{m}.3$	26° 15′	var	cG7	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 33 km. Cepheid var.
5289	27 Vul	32.8	26 7	5.52	B9	H. Plaskett, *DAO* **1**, 287, 1921. Range 55 km. pr.
5291	β Del	32.9	14 15	3.72	F5	Wilson, *LOB* **6**, 148, 1911. Range 12 km. Two spectra suspected.
5292	ι Del	33.0	11 2	5.43	A2	Mt. Wilson, *ApJ* **35**, 178, 1912. Orbit.
5294	71 Aql	33.2	− 1 27	4.51	K0	Curtis, *LOB* **3**, 86, 1905. fr.
5320	α Cyg	38.0	44 55	1.33	A2p	Lee, *ApJ* **31**, 177, 1910. Range 8 km.
5322	....	38.3	41 22	5.60	B8	Mt. Wilson, *ApJ* **35**, 178, 1912. Range 24 km. gd.
5323	δ Del	38.8	14 43	4.53	A5	Frost, *ApJ* **60**, 1924. Range 20 km. From 95 plates no per. could be established.
....	X Cyg	39.5	35 14	var	G0p	Frost, *ApJ* **25**, 60, 1907. Cepheid var. Orbit.
5330	30 Vul	40.5	24 55	5.13	K2	Lick, *ASP* **34**, 169, 1922. Range 7 km.
....	HD 197770	40.7	56 46	6.36	B3	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 26 km.
5336	ε Cyg	42.2	33 36	2.64	K0	Curtis, Burns, *LOB* **4**, 97, 1906. Range 8 km.
5361	55 Cyg	45.5	45 45	4.89	B2	Henroteau, *DO* **5**, 356, 1921. Range 15 km. gd.
5370	T Vul	47.2	27 53	var	F8p	Frost, *ApJ* **20**, 296, 1904. Cepheid var. Type A9–G1, Shapley. Orbit.
....	Y Cyg	48.1	34 17	var	B2	Plaskett, *DAO* **1**, 213, 1920. Algol var. Two spectra. Orbit.
5375	57 Cyg	49.7	44 0	4.68	B3	Frost, Adams, *ApJ* **17**, 381, 1903. Two spectra. Orbit.
5384	16 Del	50.9	12 11	5.54	A2	H. Plaskett, *DAO* **1**, 287, 1921. Range 31 km. pr.
....	UY Cyg	52.3	30 3	var	F0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 6 km.
5390	α Oct	52.6	−77 24	5.24	F2	Chile Sta. *ASP* **34**, 169, 1922. Range 71 km.
....	HD 199579	53.1	44 33	6.01	Oe5	Rufus, *ApJ* **51**, 252, 1920. Orbit.
5393	ν Cyg	53.4	40 47	4.04	A0	*Rep Chief Astronomer Can.*, 251, 1911.
5410	f^1 Cyg	56.4	47 8	4.86	B0p	Curtiss, *DetO* **2**, 36, 1916. Bright Hydrogen lines.
....	HD 200595	59.3	45 27	6.23	B8	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 58 km.
5425	....	21 0.1	41 14	6.33	F2	Bottlinger, *AN* **198**, 154, 1914.
....	HR 8074	0.3	46 29	6.30	A5	Plaskett, *RASC* **13**, 61, 1919. Two spectra. Rel. vel. 125 km. pr.
5431	ξ Cyg	1.3	43 32	3.92	K5	Campbell, *LOB* **4**, 162, 1907. Range 5 km.
5439	ο Pav	4.0	−70 32	5.08	Ma	Chile Sta., *LOB* **8**, 127, 1914. Range 16 km.
5442	....	4.4	29 48	5.57	A0	Young, *RASC* **13**, 61, 1919. Orbit.
5446	....	6.6	−39 50	5.26	F5	Chile Sta., *LOB* **9**, 38, 1916. Range 38 km. gd. Two spectra suspected.
5447	....	7.2	53 9	5.73	B9	Plaskett, *RASC* **13**, 61, 1919. Range 20 km. gd.
5452	ζ Cyg	8.7	29 49	3.40	K0	Stebbins, Burns, *LOB* **4**, 97, 1906. Range 7 km.
5455	δ Equ	9.6	9 36	4.61	F5	Campbell, *LOB* **1**, 23, 1901. Two spectra. Vis. bin. of shortest known period. From Lewis's orbit, Miss Hobe computes, $a_1+a_2=883{,}900{,}000$ km; $m_1+m_2=6.36\odot$; $\pi=0''.05+$.
....	SW Aqr	10.2	− 0 20	var	A3	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 71 km.
5460	τ Cyg	10.8	37 37	3.82	F0	Barrett, *AN* **177**, 174, 1908. Btr. of vis. double. Orbit.
5461	α Equ	10.8	4 50	4.14	A8p	Wright, *LOB* **1**, 159, 1902. Range 25 km. pr.
....	HR 8136	12.2	47 33	6.32	B5	Plaskett, *RASC* **12**, 462, 1918. Range 62 km. pr.
5469	σ Cyg	13.5	38 59	4.28	A0p	Campbell, *LOB* **5**, 176, 1910. Range 8 km. fr. Orbit.
....	HR 8153	14.6	58 10	6.41	B3	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 123 km. One of Hubble's neb. stars, Hα brt. B3.
5474	A Cyg	14.7	43 31	5.06	Oe5	Rufus, *ApJ* **51**, 252, 1920. Range 83 km. *DAO*, 1924.
5478	....	16.0	49 5	5.65	B5	Young, *DAO* **1**, 163, 1920. Range 28 km. pr.
....	HR 8170	17.2	39 55	6.46	F8	Plaskett, *RASC* **13**, 61, 1919. Orbit.
5488	6 Cep	17.3	64 27	5.18	B3p	Hnatek, *AN* **210**, 246, 1919. Two spectra. Rel. vel. 113 km.
5491	β Equ	17.9	6 23	5.14	A0	Mitchell, *AN* **177**, 174, 1908. Two spectra. Per. $22^{d}.7$.
5495	....	18.5	48 58	5.87	K0	H. Plaskett, *DAO* **1**, 287, 1921. Range 10 km.
5507	ζ Cap	21.0	−22 51	3.86	G5p	Campbell, Albrecht, *LOB* **5**, 176, 1910. Range 5 km.
5528	Σ 2803	26.6	52 30	7.17	A0	Harper, *DAO* **1**, 287, 1921. Range 68 km. Complex spectrum suspected.
5531	....	27.0	52 31	6.08	A0	Young, *RASC* **13**, 61, 1919. Range 25 km. fr.
5532	β Cep	27.4	70 7	3.32	B1	Adams, *ApJ* **15**, 340, 1902. Cepheid var. Orbit.
5536	....	28.9	75 58	7.67	F0	Plaskett, *DAO* **1**, 287, 1921. Range 117 km. gd.
5544	ν Oct	30.4	−77 50	3.74	K0	Wright, *LOB* **5**, 61, 1908. Range 9 km.
5549	ε Cap	31 5	−19 55	4.72	B5p	Slipher, *LowOB* **1**, 58, 1904. Range 46 km. Two spectra suspected.

TABLE I—Continued.

Boss	Star	R.A., 1900		Decl.	Mag.	Class	Discoverer and Reference
5552	3 Peg	21^{h}	$32^{\text{m}}7$	6° 10′	6.34	A0	Harper, *DAO* **1**, 287, 1921. Range 33 km. fr.
5562	γ Cap		34.6	−17 7	3.80	F0p	Young, *LOB* **6**, 148, 1911. HCO composite spectrum. Range 9 km.
5565	....		35.8	57 2	5.64	Oe5	Rufus, *ApJ* **51**, 252, 1920. Orbit.
5566	42 Cap		36.1	−14 30	5.28	G5	Lunt, *ApJ* **47**, 134, 1918. Orbit.
5573	76 Cyg		37.5	40 21	6.05	A0	Mt. Wilson, *ApJ* **35**, 178, 1912. Range 36 km. fr.
5579	77 Cyg		38.4	40 37	5.48	A0	Young, *RASC* **13**, 61, 1919. Two spectra. Rel. vel. 177 km.
5580	π Cyg		38.5	50 44	4.78	B3	Young, *LOB* **6**, 149, 1911. Range 28 km. Two spectra suspected.
5581	45 Cap		38.6	−15 12	5.90	A5	Mt. Wilson, *ApJ* **35**, 178, 1912. Range 32 km. pr.
5582	ι Ps A		39.0	−33 29	4.35	A0	Curtis, *LOB* **5**, 140, 1909. Two spectra. Rel. vel. 175 km.
5589	c Cap		39.7	− 9 32	5.28	K0	Lick, *ASP* **34**, 169, 1922. Range 5 km.
5591	....		39.9	28 19	6.90	A5	Adams, Joy, *ASP* **31**, 42, 1919. Two spectra. Orbit.
5592	κ Peg		40.1	25 11	4.27	F5	Campbell, *ApJ* **12**, 257, 1900. Vis. bin. Orbit.
5593	μ Cep		40.4	58 19	var	Ma	Lick, *LOB* **7**, 102, 1912. Range 13 km.
5600	δ Cap		41.5	−16 35	2.98	A5	Slipher, *ApJ* **24**, 361, 1906. Orbit.
5609	π^2 Cyg		43.1	48 51	4.26	B3	Moore, *LOB* **6**, 149, 1911. Range 13 km. Two spectra suspected.
5617	14 Peg		45.4	29 43	5.00	A0	Merrill, *LOB* **6**, 149, 1911. Two spectra. Rel. vel. 74 km.
5620	Σ 2836		46.8	66 20	6.51	F2	H. Plaskett, *DAO* **1**, 163, 1920. Range 60 km. gd.
....	VZ Cyg		47.7	42 40	var	cF8	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 23 km. Cepheid var.
5650	....		53.8	63 9	5.35	Map	Lick, *ASP* **34**, 169, 1922. Range 17 km. brt H.
....	RT Lac		57.5	43 24	var	G8	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Algol var. Two spectra. Rel. vel. 180 km.
5671	32 Aqr		59.6	− 1 23	5.23	A3	Lick, *ASP* **34**, 169, 1922. Range 14 km. F0.
5680	33 Aqr	22	1.0	−14 21	4.35	B8	Lee, *ApJ* **39**, 42, 1914. Two spectra.
....	HR 8422		1.8	44 37	6.42	A0	Young, *RASC* **13**, 194, 1919. Range 33 km. fr.
5683	....		1.9	82 23	7.79	F5	Adams, Joy, *ASP* **31**, 42, 1919. Ftr. of vis. bin. Σ2873. Two spectra. Rel. vel. 175 km. G4p.
....	HR 8427		2.0	47 45	6.16	B3	Young, *RASC* **13**, 194, 1919. Orbit.
5688	ι Peg		2.4	24 51	3.96	F5	Campbell, *ApJ* **9**, 310, 1899. Orbit. Belopolsky, *AN* **154**, 210, 1901.
5692	25 Peg		3.1	21 13	5.66	B8	Mt. Wilson, *ApJ* **35**, 179, 1912. Range 23 km. fr.
....	HR 8441		3.7	25 3	6.03	F0	Young, *DAO* **1**, 163, 1920. Range 20 km. pr.
5700	....		4.7	47 27	6.83	A0	H. Plaskett, *DAO* **1**, 287, 1921. Range 28 km. gd.
5703	θ Peg		5.2	5 42	3.70	A2	Lee, *ApJ* **31**, 179, 1910. Two spectra.
....	C 2889		5.9	22 18	8.8	K2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 21 km.
5714	ζ Cep		7.4	57 42	3.62	K0	Moore, *LOB* **4**, 162, 1907. Range 6 km.
5733	μ^1 Gru		9.6	−41 51	4.86	G0	Chile Sta., *ASP* **34**, 169, 1922. Range 13 km.
5738	....		10.7	62 40	6.21	B9	Mt. Wilson, *ApJ* **35**, 179, 1912. Range 43 km. pr.
5747	α Tuc		11.7	−60 45	2.91	K2	Paddock, *LOB* **6**, 152, 1911. Range 9 km.
5753	....		14.3	65 38	7.00	A0	Harper, *DAO* **1**, 163, 1920. Range 33 km. gd.
5761	γ Aqr		16.5	− 1 53	3.97	A0	Plaskett, *RASC* **2**, 272, 1908. Range 42 km. Cannon, *DO* **1**, 409, 1913, from 109 plates is unable to find per. which fits all observations. Per. $58^{\text{d}}1$ is most satisfactory.
5764	2 Lac		16.9	46 2	4.66	B5	Frost, Adams, *ApJ* **18**, 387, 1903. Two spectra. Orbit.
5771	....		18.8	66 12	6.74	A2	Young, *DAO* **1**, 287, 1921. Range 50 km. gd.
5784	....		21.3	85 36	5.38	A0	Struve, *ApJ* **60**, 1924. Range 40 km. Two spectra suspected.
....	Grm 3781		23.1	69 23	8.0	K0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 34 km.
5803	σ Aqr		25.4	−11 11	4.89	A0	Wilson, *LOB* **6**, 149, 1911. Range 14 km. gd.
5805	δ Cep		25.4	57 54	var	G0	Belopolsky, *ApJ* **1**, 160, 1895. Cepheid var. Type F0–G2, Shapley. Orbit.
5810	6 Lac		26.2	42 37	4.54	B3	Frost, Adams, *ApJ* **18**, 383, 1903.
5818	29 Cep		29.0	78 19	5.50	A2	Hnatek, *AN* **214**, 279, 1921. Range 31 km. (2 plates.)
5827	....		30.5	75 43	5.74	A0	H. Plaskett, *DAO* **1**, 163, 1920. Range 34 km. fr. Hnatek, *AN* **214**, 279, 1921, suspects two spectra.
5833	8 Lac		31.4	39 7	5.36	B5	Mt. Wilson, *ApJ* **35**, 179, 1912. Range 46 km. pr.
5844	10 Lac		34.8	38 32	4.91	Oe5	Frost, *ApJ* **40**, 272, 1914. Range 20 km.
5848	30 Cep		35.1	63 4	5.21	A2	Mt. Wilson, *ApJ* **35**, 179, 1912. Range 45 km. pr. Hnatek, *AN* **214**, 279, 1921. Two spectra. Rel. vel. 207 km.
5850	β Oct		35.8	−81 54	4.34	F0	Moore, *LOB* **6**, 152, 1911. Range 29 km. pr.
....	Z Lac		36.9	56 18	var	cF5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 38 km. Cepheid var. cG0.
5856	12 Lac		37.0	39 42	5.18	B2	Mt. Wilson, *ApJ* **35**, 179, 1912. Orbit.

TABLE I—Concluded.

Boss	Star	R.A., 1900	Decl.	Mag.	Class	Discoverer and Reference
5865	η Peg	22^{h} $38^{m}3$	29° 42′	3.10	G0	Campbell, *ApJ* **8**, 159, 1898. Orbit.
5867	η Gru	39.5	−54 2	4.86	K0	Chile Sta., *LOB* **8**, 76, 1914. Range 9 km.
5890	14 Lac	45.9	41 25	5.84	B5	Adams, Joy, *ASP* **29**, 259, 1917. Two spectra. B3p.
5900	....	48.1	16 19	5.72	K0	Harper, *DAO* **1**, 163, 1920. Orbit.
....	SW Lac	49.2	37 23	var	G2p	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Algol var. Two spectra. Rel. vel. 400 km.
5913	16 Lac	51.8	41 4	5.54	B3	Yerkes, *ApJ* **32**, 307, 1910. Two spectra suspected. H and K give constant vel.
5918	....	52.7	48 9	5.20	B3	Plaskett, *RASC* **12**, 462, 1918. Range 39 km. Frost, *ApJ* **49**, 61, 1918. Possibly two spectra.
5926	ζ Gru	55.0	−53 17	4.18	G5	Wright, *LOB* **6**, 56, 1910.
5933	ο And	57.3	41 47	3.63	B5 A2p	Wright, *LOB* **1**, 159, 1902.
5935	π Ps A	58.0	−35 17	5.13	F0	Chile Sta. *LOB* **8**, 76, 1914. Range 36 km.
5936	2 And	58.0	42 13	5.08	A2	H. Plaskett, *DAO* **1**, 287, 1921. Range 32 km.
5940	β Peg	58.9	27 32	2.61	Mb	Mellor, *Det O* **3**, 92, 1917. Per. 52^{d}±.
5944	α Peg	59.8	14 40	2.57	A0	Yerkes, *ApJ* **32**, 308, 1910. Two spectra.
5954	56 Peg	23 2.2	24 56	4.98	K0	Young, *LOB* **6**, 149, 1911. Range 5 km.
5955	1 Cas	2.4	58 53	4.93	B1	Frost, Harper, *RASC* **9**, 128, 1915. Range 16 km.
....	HR 8800	2.7	45 33	6.56	B5	Young, *RASC* **13**, 194, 1919. Orbit.
....	HR 8803	3.0	59 13	6.28	B3	Plaskett, *RASC* **12**, 462, 1918. Two spectra. Orbit.
5965	ι Gru	4.7	−45 47	4.10	K0	Wright, Curtis, *LOB* **4**, 161, 1907. Orbit.
5966	π Cep	4.7	74 51	4.56	G5	Wright, *LOB* **1**, 22, 1901. Btr. comp. of close vis. bin.
5975	7 And	8.0	48 52	4.62	F0	Yerkes, *ApJ* **39**, 273, 1914.
5977 ftr.		8.9	− 9 28	8.3	G0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 37 km.
5987	....	11.8	70 21	5.62	A3	Hnatek, *AN* **214**, 279, 1921. Range 74 km. (2 plates.)
5996	9 And	13.6	41 14	5.90	A3	Adams, *ASP* **28**, 80, 1916. Orbit.
5998	94 Aqr	13.9	−14 00	5.27	G5	Lick, *ASP* **34**, 169, 1922. Range 11 km. G5.
5999	96 Aqr	14.2	− 5 40	5.70	F2	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 63 km.
6011	65 Peg	17.7	20 17	6.22	A0	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 50 km.
6034	13 And	22.3	42 22	5.65	B9	Plaskett, *RASC* **13**, 61, 1919. Range 20 km. gd.
6046	1 Cas	25.4	58 0	4.89	B3	Frost, Adams, *ApJ* **18**, 383, 1903. Orbit.
....	β GC 12404	25.5	30 16	7.26	F5	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Range 50 km. Two spectra suspected. Close double, dis. 0″2.
6070	74 Peg	32.6	16 16	6.18	A0	Plaskett, *RASC* **13**, 194, 1913. Range 32 km. gd.
6071	λ And	32.7	45 55	4.00	K0	Campbell, *ApJ* **10**, 178, 1899. Orbit.
6072	75 Peg	32.9	17 51	5.42	A0	Plaskett, *RASC* **13**, 194, 1919. Range 35 km. pr.
6073	ι And	33.2	42 43	4.28	B8	Barrett, *Sci* **28**, 853, 1908.
6075	18 And	34.3	49 55	5.32	B9	Mt. Wilson, *ApJ* **35**, 179, 1912. Range 40 km. pr.
6084	λ Psc	36.9	1 14	4.61	A5	Lee, *ApJ* **39**, 42, 1914. Two spectra suspected. gd.
6108	....	43.1	67 15	5.02	A0	Barrett, *ApJ* **60**, 1924. Range 30 km.
6129	....	47.5	74 59	6.55	K2	Adams, Joy, *ASP* **29**, 113, 1917.
....	Lal 46867	50.0	28 5	7.30	K0	Adams, Joy, *ASP* **31**, 42, 1919. Orbit.
6142	....	50.5	56 51	6.05	B0	Mt. Wilson, *ApJ* **35**, 179, 1912. Two spectra. Orbit.
6148	....	52.1	55 9	5.69	F5	H. Plaskett, *DAO* **1**, 163, 1920. Two spectra. Orbit.
....	U Peg	52.9	15 24	var	F3	Adams, Joy, Sanford, *ASP* **36**, 137, 1924. Algol var. Two spectra. Rel. vel. 195 km.
6173	ζ Scl	57.2	−30 17	4.99	B5	Paddock, *LOB* **6**, 4, 1910. Range 20 km. gd.
6182	3 Cet	59.4	−11 4	5.16	K2	Lick, *ASP* **34**, 169, 1922. Range 11 km. M6.

TABLE II.

Boss	Star	R.A. 1900	Decl.	Mag.	Class	Discoverer and Reference
37	....	0^{h} $10^{m}6$	76°24′	6.23	B9	H. Plaskett, *DAO* **1**, 287, 1921. Withdrawn in *RASC* **18**, 1924.
68	12 Cas	19.3	61 17	5.39	B9	Mt. Wilson, *ApJ* **35**, 172, 1912. Adams (letter) says very poor spectrum. Probable.
135	α Cas	34.8	55 59	2.47	K0	Mellor *Det O* **3**, 78, 1917. Range 8.5. Probable.
182	λ Hyi	45.1	−75 28	4.96	K5	Mrs. Moore, *LOB* **6**, 55, 1910. Range reduced to 4.8 km. by correction of error in reduction and application of systematic corrections. Lunt finds range of 2.4 km. Probable.
199	γ Cas	50.7	60 11	2.25	B0p	Hartmann, *AN* **173**, 102, 1906. Range 22 km. Ann Arbor and Lick observations do not show any variation. Curtiss. *Det O* **2**, 1, 1915.
212	α Scl	53.8	−29 54	4.39	B5	*LOB* **6**, 108, 1911. Announced as binary in a list of radial velocities. Range of 9 km too small for this type of spectrum. Probable.

TABLE II—Continued.

Boss	Star	R.A., 1900		Decl.	Mag.	Class	Discoverer and Reference
259	β And	1^{h}	$4^{m}1$	35° 5′	2.37	Ma	Young, Wilson, *LOB* **6**, 141, 1911. Range reduced to 2.7 km. by application of systematic corrections. Probable.
304	ξ And		16.4	45 0	4.99	K0	Miss Hobe, *LOB* **6**, 141, 1911. Range reduced to 3.4 km. by application of systematic corrections. Probable.
348	....		30.5	16 55	5.88	A5	H. Plaskett, *DAO* **1**, 287, 1921. Withdrawn in *RASC* **18**, 1924.
429	ψ Phe		49.6	−46 48	4.41	Mb	Suspected by Lunt, *ApJ* **50**, 168, 1918.
438	χ Eri		52.1	−52 6	3.73	G5	Lunt, *ApJ* **48**, 270, 1918. Lunt (unpublished) says "probably not variable."
477	α Ari	2	1.6	22 59	2.23	K2	Mellor *Det O* **3**, 80, 1917. Range 7.5, suspects variable velocity.
545	65 And		18.9	49 50	4.86	K5	Olivier, *LOB* **6**, 142, 1911. Range reduced to 2.4 km. by application of systematic corrections and excluding one poor observation. Probable.
671	4 Eri		52.9	−24 16	5.41	A5	Campbell, *ASP* **34**, 169, 1922. Lines change in width. Probable.
740	30 Per	3	11.0	43 39	5.38	B5	Mt. Wilson, *ApJ* **35**, 173, 1912. Adams (letter) says very poor spectrum. Probable.
772	α Per		17.2	49 30	1.90	F5	Goos, *AN*, **180**, 57, 1909. See Note 1 at end of Table II.
860	20 Tau		39.9	24 4	4.02	B5	Adams *ApJ*, **19**, 341, 1904. From a series of 44 plates (1912–1913) Merrill finds no certain evidence of variable velocity. *Det O* **1**, 138, 1914.
996	α Ret	4	13.1	−62 43	3.36	G5	Suspected by Lunt *ApJ* **48**, 270, 1919. Lunt (unpublished) says "probably not variable." Lick observations show no variation.
1023	66 Tau		18.4	9 14	5.06	A2	Plaskett, *ApJ* **39**, 264, 1914. Appears in a list of binaries under observation at Ottawa.
1140	π Ori		44.4	6 47	3.31	F8	Suspected by Lunt, *ApJ* **48**, 270, 1918.
1390	ν^2 Col	5	33.8	−28 45	5.32	F2	Lunt, *CA* **10**, 9 E, Range 11, lines hazy. Probable.
1396	126 Tau		35.6	16 29	4.87	B3	Henroteau, *DO* **5**, 66, 1921. Probable.
1717	ε Gem	6	37.8	25 14	3.18	G5	Suspected by Lunt, *ApJ* **48**, 270, 1918.
1776	15 Lyn		48.6	58 33	4.54	G0	Wilson, *LOB* **6**, 145, 1911. Range reduced to 3 km. by applying systematic corrections and excluding 2 poor plates. Probable.
1781	15 C Ma		49.2	−20 6	4.66	B1	Campbell, *LOB* **6**, 145, 1911. Range reduced to 10 km. by remeasurement of plates. Probable.
1805	t Pup		54.8	−33 59	5.07	B5	Suspected by Campbell, *ASP* **34**, 169, 1922. Lines change in width. Probable.
1867	γ Vol	7	9.6	−70 20	3.87	K0	Suspected by Lunt, *ApJ* **48**, 270, 1918.
	AGC 9455		19.2	−31 41	5.43	B	Suspected by Campbell, *ASP* **34**, 169, 1922. Lines change in width. Probable.
2065	ξ Pup		45.1	−24 37	3.47	G0p	Lunt, *ApJ* **48**, 270, 1918. Probably not variable. (Unpublished.)
2108			53.7	−30 4	4.85	A2	*LOB* **7**, 22, 1912. Noted as binary in list of radial velocities. Range only 3.5 km. Probably not variable velocity.
2400	62 Cnc	8	51.7	15 43	5.16	A3	Mt. Wilson, *ApJ* **35**, 175, 1912. Adams (in letter) says results show constant velocity.
2407	α Cnc		53.0	12 14	4.27	A3	Adams, *ApJ* **35**, 175, 1912. Adams (letter) says removal of errors in reduction leaves velocity constant. Young finds a range of 33 km., but is not certain that it is binary. *RASC* **11**, 219, 1917.
2451	19 Hya	9	3.8	− 8 11	5.50	B8	Mt. Wilson, *ApJ* **35**, 175, 1912. Adams (letter) says spectrum very poor. It may be binary.
2538	ω Leo brt.		23.1	9 30	5.52	G0	Frost, *ApJ* **25**, 61, 1907. Disproved. Frost *ApJ* **48**, 258, 1918.
2544	ε Ant		25.1	−35 31	4.64	K2	Mrs. Moore, *LOB* **6**, 151, 1911. Range reduced to 3.0 km. by application of systematic corrections and excluding 1 plate. Lunt finds range of 4.4 km. Probable.
2604	m Car		36.6	−60 53	4.67	B9	Paddock, *LOB* **6**, 112, 1911. Range of 8 km. too small. Probable.
2728	35 Leo	10	11.0	24 0	5.91	G0	Harper, *DAO* **2**, 189, 1923. Range 13 km. Probable.
2742	γ Leo		14.5	20 21	2.61	K0	Belopolsky, *AN* **147**, 89, 1898. Visual binary. Belopolsky finds relative velocity of two components of 2.2 km. Lick observations show a difference of 0.1 km. for the two components.
2743					3.80		
2804	ρ Leo		27.5	9 49	3.85	Bop	Schlesinger, *ApJ* **41**, 166, 1915. App. orbit. Dawson, *Det. O.* **2**, 158, 1915, from 43 Ann Arbor observations finds no evidence of variable velocity in period of 12.28 days announced by Schlesinger.

TABLE II—Concluded.

Boss	Star	R.A., 1900		Decl.	Mag.	Class	Discoverer and Reference
2823	τ Car	10^{h}	$31^{m}.7$	−57° 2′	4.54	K5	Mrs. Moore, *LOB* **6**, 151, 1911. Range reduced to 5.8 km. by applying systematic corrections and this depends on one plate. Probable.
2930	β U Ma		55.8	56 55	2.44	A0	Ludendorff *AN* **177**, 235, 1908. See note 2 at end of Table II.
2974	θ Leo	11	9.0	15 59	3.41	A0	Henroteau *Det O* **3**, 56, 1917. Probable.
2989	δ Crt		14.3	−14 14	3.82	K0	Lunt, *ApJ* **50**, 170, 1919. Lunt's later observations show range of 4 km. (Unpublished.) Probable.
3011	80 Leo		20.7	4 25	6.36	F0	H. Plaskett, *DAO* **1**, 287, 1921. Withdrawn in *RASC* **18**, 1924.
3042	ξ Hya		28.1	−31 18	3.72	G5	Suspected by Lunt, *ApJ*, **48**, 270, 1918. Probable.
3117	γ U Ma		48.6	54 15	2.54	A0	Mellor *Det O* **3**, 71, 1917. Range 38 km., pr. Probable.
	HD 103928		53.0	32 50	6.30	F0	Henroteau *Det O*, **3**, 57, 1917. Range 20 km. Probable.
3160	η Cru	12	1.7	−64 3	4.30	F0	Lunt, *ApJ* **50**, 170, 1919. Probable.
	BD+41°2307		22.6	41 55	6.85	F5 A3	Harper *DAO* **2**, 189, 1923. Apparently complex spect. Probable.
3307	γ Vir		36.6	− 0 54.	3.65	F0	Belopolsky, *AN* **147**, 89, 1898. Visual binary. Belopolsky finds relative velocity of two components 2.1 km. Lick observations do not confirm.
3552	....	13	42.0	41 35	5.69	A3	Henroteau *Det O* **3**, 57, 1917. Range 44 km. Probable.
3809	β U Mi	14	51.0	74 34	2.24	K5	Mellor *Det O* **3**, 88, 1917. Range 8 km. Suspected.
4134	δ Oph	16	9.1	− 3 26	3.03	Ma	Lunt, *ApJ* **48**, 270, 1918. *ApJ* **52**, 317, 1920, Lunt withdraws on account of error in reduction to Sun.
4255	η Her		39.5	39 7	3.61	K0	Lick, *LOB* **6**, 147, 1911. Range reduced to 3.1 km. by application of systematic corrections. Probable.
4371	....	17	9.7	−26 27	5.29	K0	Mrs. Moore, *LOB* **6**, 57, 1910. Range reduced to 2.5 km. by applying systematic corrections and excluding 1 poor plate. Probable.
4492	ι Sco		40.6	−40 5	3.14	F5p	Lunt, *ApJ* **48**, 274, 1918. Probable.
4548	67 Oph		55.6	2 56	3.92	B5p	Plaskett, *ApJ* **39**, 266, 1914. Appears in a list of binaries under observations at Ottawa.
4636	106 Her	18	16.1	21 55	4.98	K5	Wilson, *LOB* **6**, 147, 1911. Range reduced to 3.3 km. by application of systematic corrections. Probable.
4638	η Ser		16.1	− 2 55	3.42	K0	Lunt, *ApJ* **48**, 271, 1918. Lunt withdraws on account of errors in reduction. *ApJ* **52**, 317, 1920.
4764	29 Sgr		43.8	−20 26	5.37	K0	Lunt, *CA* **10**, 16 E, Range 9 km. Probable.
4906	ι Vul	19	11.9	21 13	4.60	B5	Henroteau *DO* **5**, 349, 1921, pr. Probable.
5102	22 Cyg		52.3	38 13	4.87	B3	Appears in a list of binaries under observation at Yerkes, *ApJ* **39**, 273, 1914. Frost (letter) says that there is no evidence of variable velocity.
5126	....		56.2	45 30	5.80	A2	H. Plaskett, *DAO* **1**, 287, 1921. Withdrawn in *RASC* **18**, 1924.
5332	ι Mic	20	41.7	−44 21	5.14	F0	*LOB* **7**, 26, 1912. Announced in a list of radial velocities. Probably not variable velocity.
5484	ι Cap	21	16.7	−17 16	4.30	K0	Moore, *LOB* **4**, 97, 1906. Withdrawn in *LOB* **7**, 102, 1912, on account of errors in reduction.
5716	24 Cep	22	7.9	71 51	4.99	G5	Miss Hobe, *LOB* **6**, 149, 1911. Range reduced to 2.7 km. by excluding 1 poor plate. Probable.
5732	....		9.6	39 13	4.64	K2	Miss Allen, *LOB* **5**, 176, 1910. Range reduced to 3 km. by excluding poor plate. Probable.
5931	....		55.9	56 25	5.48	G0p	Harper, *DAO* **2**, 189, 1923. Range 12 km. Probable.
5988	γ Psc	23	12.0	2 44	3.85	K0	Suspected by Campbell, *LOB* **6**, 153, 1911. Probable.
6040	70 Peg		24.1	12 13	4.67	K0	Miss Hobe, *LOB* **6**, 149, 1911. Range reduced to 3.5 km. by application of systematic corrections. Probable.
6084	78 Peg		39.0	28 49	4.98	K0	Wilson, *LOB* **6**, 149, 1911. Range reduced to 3.5 km. by applying systematic corrections. Probable.

Note 1: α Per. Goos represents his observations by a circular orbit, with a period of 290 days and amplitude 1.4 km/sec. Hnatek (*AN* **192**, 245, 1912) is able to represent his observations by an orbit with period 4.0938 days, eccentricity 0.47, and amplitude 1.86 km/sec.

Pitman (*LOB* **7**, 99, 1912) from a discussion of all observations has shown that they are better represented by a straight line than by the curves of Goos or Hnatek and that the observed variation in velocity is very doubtful.

Note 2: β U Ma. Ludendorff found Potsdam observations satisfied by a period of 27.16 days and published an orbit for this star in *AN* **180**, 271, 1908. The 36 Lick observations 1901 to 1914 show no relationship to Ludendorff's curve or evidence of variable velocity greater than the error of measure for spectra of this character. Guthnick and Prager, from observations with photo-electric photometer at Berlin-Babelsberg, found that its light varies through a range of 0.02 magnitude in a period of 0.3122 mean solar days. They were able to represent Ludendorff's spectrographic observations with the same period by an orbit whose eccentricity is 0.23, with maximum and minimum radial velocities −11.5 and −17.4 km/sec. Three series of plates were taken at Mount Hamilton on three nights in 1916, each series covering more than a whole period, and another series in 1917. Although Guthnick and Prager have computed orbits from the 1916 and 1917 series, using a period of $0^{d}.31234$ (*Ver. D. Univ. Sternwarte Ber. Babelsberg*, **2**, 62, 1919) from velocity curves of amplitude 1.25 km/sec., the reality of this short period variation is still doubtful and it is a question whether the radial velocity of this star is to be considered as variable.

TABLE III

Boss	Star	R.A., 1900		Decl.		Mag.	Class	P.	T Jul. Day 2,410,000+	ω	e	K_1 km.	$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$	$a_1 \sin i$ 1,000 km.
10	α And	0^{h}	$3^{m}2$	28°	32′	2.15	A0p	96.67	7882.40	76°21	0.525	30.75	(0.180)	34,790
								96.7	6817	69.4	0.50	27.25	0.13	31,400
46	....		12.4	50	53	6.12	B0	3.5225	11231.865	323.0	0.094	217.4	3.71	10,480
....	T V Cas		13.9	58	35	var	B9	1.812635†	−0.0045*	....	0	87.92	....	....
												150		
78	α Phe		21.3	−42	51	2.44	K0	3848.83	6201.85	19.822	0.335	5.76	0.06389	290,000
82	....		22.8	43	50	5.16	A2	3.95583	8841.590	233.2	0.152	41.7	0.02877	2,240
116	13 Cet		30.1	− 4	9	5.24	G0	2.0818	7484.494	222.7	0.09	36.4	0.01030	1,037
								2.0810	8265.260	230.6	0.07	36.3	....	1,036
								2.0866	9716.5706	285.02	0.105	34.18	....	975
123	π And		31.5	33	10	4.44	B3	143.67	8564.144	350.53	0.573	47.66	0.8894	77,200
145	π Cas		37.9	46	29	5.02	A5	1.96408	9970.035	45.1	0.010	117.32	....	3,168
										225.1	....	118.97	....	3,213
146	ρ Tuc		38.2	−66	1	5.46	F5	4.820223	9299.106	269.01	0.02	25.7	0.008492	1,700
159	23 Cas		41.1	74	18	5.39	B8	33.75	10577.41	269.71	0.405	16.32	0.01214	7,020
164	ζ And		42.0	23	43	4.30	K0	17.7673	10024.881	182.22	0.037	25.69	0.03122	6,272
175	ν And		44.3	40	32	4.42	B3	4.28284	8155.661*	....	0.0	75.63	0.1924	4,454
												104	....	6,125
325	α U Mi	1	22.6	88	46	2.12	F8	3.96809	4147.92	69.80	0.09	3.03	....	164.7
								3.96809	13738.56	47.29	0.19	2.74	0.000007840	146.9
329	γ Phe		24.0	−43	50	3.40	K5	193.79	7945.0	267	0.005	15.8	0.079	42,100
373	Σ 145 btr.		35.7	25	14	6.26	F5	4.43474	11940.9865	295.58	0.108	81.5	....	4,942
										115.58	....	88.6	....	5,372
384	φ Per		37.4	50	11	4.19	B0p	126.5	8290.42	347.29	0.428	26.90	0.1888	44,803
								63.25*	8324.37	257.14	0.107	6.96		
								126.6	8548	6.6	0.39	40.5		
421	α Tri		47.4	29	6	3.58	F5	1.73652	10793.821	135.56	0.121	12.10	0.0003124	287
425	ω Cas		48.2	68	12	5.03	B8	69.92	10426.02	49.97	0.30	29.64	0.164	27,190
428	β Ari		49.1	20	19	2.72	A5	107.0	7632	19.7	0.88	32.6	0.042	22,880
497	ι Tri btr.	2	6.6	29	50	5.20	G0	14.732	1243.157	5.39	0.043	56.53	....	11,441
										185.39	....	56.98	....	11,532
497	ι Tri ftr.		6.6	29	50	6.4	A5	2.2365	1246.698	3.68	0.010	95.43	....	2,934
										183.68	....	101.04	....	3,107
514	δ Tri		10.9	33	46	5.07	G0	9.92912	13309.427	21.50	0.059	8.82	0.00070	1,200
530	ο Cet		14.3	− 3	26	var	Md	331	267	267.0	0.17	6.4	0.008624	28,000
593	Σ 5 btr.		31.2	24	13	6.57	F5	9.851	11586.899	129.6	0.1455	22.48	0.0113	3,013
....	R Z Cas		39.9	69	13	var	A0	1.19525	9449.732	154.7	0.052	69.30	0.0412	1,137

TABLE III

Boss	V_o km.	Computer	Reference	Remarks
10	−11.55	Baker	*AO* **1**, 22, 1908	Presence of second spectrum suspected by Baker, *AO* **1**, 136, 1910, and Ludendorff, *ApJ* **39**, 462, 1914. Earlier orbit by Ludendorff, *AN* **176**, 327, 1907.
	−14.4	Ludendorff	*AN* **178**, 23, 1908	
46	−44.9	Adams, Stromberg	*ApJ* **47**, 329, 1918	Two spectra. H and K give small variation. Spectral type B3.
....	+ 0.54	Plaskett	*DAO* **2**, 141, 1922	Eclipsing variable. †Photometric period McDiarmid. *Spec.-photm. phase. a (sep) $=8.86r_s$; $r_1=2.50r_s$; $r_2=2.83r_s$; $m_1=1.83\odot$; $m_2=1.01\odot$; $d_1=0.118D_o$; $d_2=0.044D_o$.
78	+75.21	Lunt	*CA* **10**, 27G, 1924	Earlier orbit by Lunt, *ApJ* **47**, 196, 1918.
82	+ 2.04	Miss Udick	*AO* **2**, 194, 1912	
116	+10.3	Paraskévopoulos	*ApJ* **52**, 110, 1920	1906–7 Brighter component of very close visual double whose period is 6.88 years. Paraskévopoulos finds perturbations of the orbit of spectroscopic binary due to other component of visual pair.
	+ 9.0			1908
	+17.21			1912–13
123	+ 8.83	Jordan	*AO* **2**, 49, 1910	
145	+12.42	Harper	*DO* **4**, 149, 1917	Two spectra. $m_1 \sin^3 i=1.35\odot$; $m_2 \sin^3 i=1.34\odot$ Orbit of secondary.
146	+13.55	Lunt	*CA* **10**, 41G, 1924	
159	− 4.06	Young	*DO* **2**, 194, 1915	Hnatek suspects two spectra. *AN* **210**, 246, 1919.
164	−29.83	Cannon	*DO* **2**, 157, 1915	
175	−23.91	Jordan	*AO* **1**, 196, 1910	*Time of greatest positive velocity. $m_1 \sin^3 i=1.50\odot$; $m_2 \sin^3 i=1.10\odot$ Orbit of secondary.
325	−11.54	Moore, Kholodovsky	*LOB* **11**, 1924	1899 Cepheid variable. Velocity of system variable in a period of more than 30 years. Belopolsky from Potsdam, Lick, and Poulkova observations, 1896–1920, finds a rotation of line of apsides with period of about 7 years. Moore and Kholodovsky, *LOB* **11**, 1924, from a discussion of Lick observations, 1899–1923, find small changes in the elements ω, e, K, but do not confirm Belopolsky's conclusion concerning the variation of ω in a period of 7 years.
	−17.52	Kholodovsky	*LOB* **11**, 1924	1923
329	+25.8	Wilson	*LOB* **9**, 116, 1918	
373	+ 4.6	Sanford	*ApJ* **53**, 201, 1921	Two spectra. Adams and Joy spectral type F3. Orbit of secondary. $m_1 \sin^3 i=1.16\odot$; $m_2 \sin^3 i=1.06\odot$
384	+ 3.20	Cannon	*RASC* **4**, 195, 1910	Cannon's orbit based on absorption lines Hβ, Hγ, Hδ, K, and Hε, λ4471 and λ3970. *Elliptical elements of secondary oscillation. T is here the time when up curve crosses zero line. Ludendorff's elements are from Hγ absorption line. Using these elements he finds from the weak absorption lines in which he observes two components, $m_1 \sin^3 i=1.1\odot$; $m_2 \sin^3 i=2.5\odot$ The spectrum consists of emission and absorption lines, which change in intensity and character with the phase. See Jordan, *AO* **3**, 31, 1913. Ludendorff and Jordan find that different revolutions of the system give different velocity curves. No simple orbit or combination of orbits will satisfy all of the observed phenomena.
		Ludendorff	*AN* **186**, 17, 1910	
421	−12.65	Harper	*DO* **3**, 133, 1915	
425	−24.82	Young	*DO* **2**, 102, 1915	
428	− 0.6	Ludendorff	*ApJ* **25**, 325, 1907	Vogel suspected duplicity 4481 on 2 plates but Ludendorff found no evidence on 74 plates. Several lines look double on one Lick plate. For $m_1=m_2$; $m_1 \sin^3 i=m_2 \sin^3 i=0.17\odot$
497	−19.09	Harper	*DAO* **2**, 129, 1921	Two spectra. $m_1 \sin^3 i=1.120\odot$; $m_2 \sin^3 i=1.118\odot$ Orbit of secondary.
497	....	Harper	*DAO* **2**, 129, 1921	Two spectra. $m_1 \sin^3 i=0.906\odot$; $m_2 \sin^3 i=0.855\odot$ Orbit of secondary.
514	− 5.82	Pearce	*LOB* **11**, 131, 1923	
530	+57.8	Joy	*PA* **31**, 645, 1923	Joy says spectrum varies M6e–M9e, *PA* **31**, 237, 1923. Visual double, Aitken, *ASP* **35**, 323, 1923.
593	+14.42	Adams, Joy	*ApJ* **49**, 186, 1919	
....	−38.32	Jordan	*AO* **3**, 137, 1914	Algol variable. From spectrographic and photometric elements Dugan, *ApJ* **44**, 115, 1916, deduces absolute elements of system, on probable assumption that mass of smaller star = 2.7 mass of larger star and on assumption of darkening of limb. Max. radius of larger star = 1,229,000 km. Max. radius of smaller star = 1,175,000 km.; mass larger star = $0.58\odot$; mass smaller star = $1.58\odot$; density of larger star = $0.11D_o$; density smaller star = $0.34D_o$; radius of orbit = 4,258,000 km.

TABLE III—Continued.

Boss	Star	R.A., 1900		Decl.		Mag.	Class	P.	T Jul. Day 2,410,000+	ω	e	K_1 km.	$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$	$a_1 \sin i$ 1,000 km.
637	S U Cas	2^h	$43^m.0$	68°	28′	var	F5	1.9495*	10197.65	…………	0.00	11.0	0.0003	295
641	π Ari		43.7	17	3	5.30	B5	3.854	10370.259	$78^{\circ}.27$	0.042	24.77	0.0061	1,312
708	β Per	3	1.7	40	34	var	B8	2.86730	2.544*	49.27	0.029	42.37	0.0179	1,670
									2.270	21	0.031	39.9	…………	1,570
									2.264	21	0.060	41.3	0.0209	1,630
									1.506†	277.5	0.038	44.1	0.254	1,736
								**$1^y.899$	$1901^y.850$††	…………	0.000	9.4	0.0598	89,000
								1.733	1888.907†††	…………	…………	8.04	…………	71,000
								1.885	1902.793	0	0.13	10.0	…………	93,000
804	f Tau		25.4	12	36	4.28	K0	960	4889.565	326.32	0.397	8.25	0.0433	99,956
844	o Per		38.0	31	58	3.94	B1	4.41916	8217.924	…………	0.00	111.92	…………	6,801
												*160.0		
									6062.5	…………	…………	107	…………	…………
913	ξ Per		52.5	35	30	4.05	Oe5	6.951	8248.308	99.18	0.034	7.87	0.0003512	752
920	λ Tau		55.1	12	12	var	B3	3.952917*	7945.119	77.5	0.061	56.18	…………	…………
								†34.60	7831.30	…………	0.0	10.4	…………	…………
967	μ Per	4	7.6	48	9	4.28	G0	284	10061.97	301.99	0.0615	20.50	0.2539	80,000
986	b^1 Per		10.7	50	3	4.57	A2	1.52732	8956.166	151.75	0.22	41.89	…………	838
										331.75	…………	152.5	…………	3,048
……	HD 27130		11.9	16	42	8.3	G7	5.6100	13102.193	88.6	0.04	58.6	0.1166	4,517
1001	υ Eri		14.1	−34	3	3.59	B9	5.0105	7562.266	124.33	0.014	63.76	…………	4,393
										304.33	…………	64.85	…………	4,468
……	O Σ 82 btr.		17.1	14	49	7.0	F8	4.00000	12274.8123	12.74	0.060	36.1	0.0193	1,980
1018	63 Tau		17.7	16	33	5.68	A2	8.425	9819.0	190.7	0.16	36.5	0.041*	4,170*
1046	θ^2 Tau		22.9	15	39	3.62	F0	140:70	8054.723	54.16	0.717	27.12	0.09872	37,471
1076	d Tau		30.2	9	57	4.38	A3	3.57124	*9734.996	…………	0.0	76.32	0.164	3,748
								3.57122	*9734.992	…………	0.0	72.68	0.142	3,570
……	S Z Tau		31.4	18	20	var	G0	3.1484	10016.187	76.66	0.24	10.94	0.00039	4.60
1082	3 Cam		32.0	52	53	5.31	K0	121	11137.55	285	0.019	28.19	0.28	46,900
1107	94 Tau		36.2	22	46	4.33	B5	1.5047	7892.500	242.88	0.087	44.34	0.01347	914
1139	9 Cam		44.1	66	10	4.38	B0	7.9957	6480.35	90 or 270	0.30	9.0	…………	…………
1147	π_4 Ori		45.9	5	26	3.78	B3	9.5191	8279.64	152.27	0.027	25.93	0.0172	3,393
1159	π_5 Ori		49.0	2	17	3.87	B3	3.70045	*7921.64	…………	0.00	57.88	0.07451	2,945
1161	7 Cam		49.3	53	35	4.44	A2	3.8846	8281.176	217.14	0.013	35.15	0.018	1,877
1190	ζ Aur		55.5	40	56	3.94	K0	973	5122.471	330.13	0.411	23.78	1.0298	294,300
1213	66 Eri	5	1.8	− 4	47	5.19	B9	5.52242	13087.09	302.3	0.09	97	…………	7,300
												116	…………	9,400
1244	14 Aur		8.9	32	34	5.14	A2	3.789	10802.715	19.70	0.033	21.56	0.003938	1,123

TABLE III—Continued.

Boss	V_o km.	Computer	Reference	Remarks
637	− 7.0	Adams, Shapley	*ApJ* **47**, 46, 1918	Cepheid variable. Max. 5.9. Min. 6.3. *Photometric period.
641	+ 7.81	Young	*DO* **4**, 69, 1917	
708	+10.38	Belopolsky	*Mit Pulk.* **3**, 72, 1908	Several orbits by Belopolsky from 1897–1907. *T intervals after principal light minimum. †Most recent orbit for epoch 1923.66. Velocity of system variable. **Orbit of center of mass. ††T corresponds to min. radial velocity. †††T corresponds to zero velocity. Irregularity in short period velocity curve during principal eclipse, with a range of 35 km. according to McLaughlin, is attributed to rotational effect. Stebbins, *ApJ* **32**, 213, 1910, on the basis of his photometric data and spectroscopic orbits of Curtiss and Schlesinger and on assumption that mass of algol = 2×mass of companion, finds mass of Algol = 0.37 $\odot$; mass of companion = 0.18 $\odot$; radius of Algol = 1.45r_s; radius of companion = 1.66r_s; density of Algol = 0.12D_o; density of companion = 0.04D_o.
	− 1.70	Schlesinger	*AO* **1**, 30, 1908	
	+ 3.40	Curtiss	*AO* **1**, 30, 1908	
	+16.9	McLaughlin	Unpublished	
	+ 4.1	Curtiss	*ApJ* **28**, 156, 1908	
	+ 4.4	Belopolsky	*Mit Pulk* **4**, 176, 1911	
	+ 5.7	McLaughlin	Unpublished	
804	+14.18	Harper	Unpublished	Preliminary elements.
844	+18.46	Jordan	*AO* **2**, 68, 1910	Earlier orbit by Vogel, *ApJ* **17**, 212, 1903. Two spectra visible. *Orbit of secondary. $m_1 \sin^3 i=5.42\odot$; $m_2 \sin^3 i=3.79\odot$; H and K give constant velocity and same as that of system. Ludendorff's orbit from single lines based upon a remeasurement of Vogel's plates. He thinks velocity of system is variable.
	+ 8	Ludendorff	*AN* **188**, 211, 1911	
913	+15.40	Cannon	*DO* **1**, 370, 1912	Orbit from H and K lines.
920	+12.95	Schlesinger	*AO* **3**, 173, 1914	Algol variable. *Photometric period. Earlier orbits by Schlesinger *AO* **3**, 23 and 30, 1913, and by v. Aretin, *Astronomische mitt. Göttingen* **15**, 87, 1913. †Orbit of center of mass. Schlesinger considers system composed of bright star, eclipsing satellite and distant satellite of masses respectively 2.5, 1.0, and 0.4 times Sun; and at distances from centroid of bright and eclipsing bodies of 3,200,000, 8,000,000, and 50,000,000 km., respectively.
		Schlesinger	*AO* **3**, 169, 1914	
967	+ 7.83	Cannon	*DO* **2**, 365, 1915	
986	+23.09	Cannon	*DO* **1**, 298, 1911	Two spectra. $m_2/m_1=0.28$.
				Orbit of secondary from six observations.
....	+38.2	Sanford	*ApJ* **59**, 358, 1924	Member of *Taurus* stream.
1001	+17.83	Paddock	*LOB* **8**, 175, 1915	Two spectra.
				Orbit of secondary. $m_1 \sin^3 i=0.558\odot$; $m_2 \sin^3 i=0.548\odot$
... ...	+37.4	Sanford	*ApJ* **53**, 201, 1921	
1018	+36.4	Jantzen	*AN* **196**, 120, 1913 **VAG* **49**, 98, 1914	There is some doubt about the period. Member of *Hyades* group.
1046	+42.59	Plaskett	*DO* **2**, 80, 1915	Some evidence of departure from elliptic motion. The superposition of a secondary curve of half the period (70.35) improves the agreement in certain parts of curve, but makes it poorer in others. One of *Taurus* stream. $\pi=0''.023$.
1076	+28.69	Wilson	*LOB* **7**, 105, 1913	Earlier orbit Harper *DO* **1**, 125, 1913, from spectrum of secondary gives $m_2/m_1=0.47$; $m_1 \sin^3 i=2.7\odot$ Daniel's orbit based on Wilson's epoch and period. *Time when secondary crosses line of sight nearest to solar system. Eclipsing binary, Shapley, *AN* **196**, 383, 1913; *AN* **199**, 142, 1914.
	+29.23	Daniel	*AO* **3**, 96, 1914	
....	− 3.15	Haynes	*LOB* **8**, 85, 1913	Type varies from A9 to F7, Shapley, *ApJ* **44**, 273, 1916.
1082	−40.47	Cannon	*DO* **4**, 175, 1918	
1107	+13.55	Parker	*Rep. Chief Astronomer* **1**, 166, 1910	
1139	− 2.25	Lee	*ApJ* **37**, 1, 1913	Orbit is from sharp H and K lines of calcium. $i=90°$ closely. $m_2/m_1=0.35$; $m_1+m_2=0.0023\odot$
1147	+23.27	Baker	*AO* **1**, 110, 1909.	
1159	+24.20	Lee	*ApJ* **38**, 180, 1913	*Epoch of maximum positive velocity.
1161	− 8.93	Harper	*RASC* **5**, 115, 1911	
1190	+10.73	Harper	Unpublished	Preliminary elements.
1213	+34	Frost, Struve	*ApJ* **60**, 1924	Two spectra. $m_2/m_1=0.8$; $m_1 \sin^3 i=2.8\odot$; $m_2 \sin^3 i=2.2\odot$
				Orbit of secondary. A faint third component is visible between other two lines but does not partake of their velocities. Lick, *ASP* **30**, 351, 1918.
1244	−10.74	Harper	*DO* **3**, 232, 1916	

TABLE III—Continued.

Boss	Star	R.A., 1900	Decl.		Mag.	Class	P.	T Jul. Day 2,410,000+	ω	e	K_1 km.	$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$	$a_1 \sin i$ 1,000 km.
1246	α Aur	5^{h} $9^{m}3$	45°	54′	0.21	G0	104.022	4899.5	117°3	0.0164	25.76	....	36,848
									*297.3	....	32.45	....	46,430
							104.022	12596.79	114.30	0.0086	....	....	....
1250	β Ori	9.7	− 8	19	0.34	B8p	21.90	7968.80	254.76	0.296	3.771	0.00011	1,109
1275		14.8	29	28	5.72	A0	27.43	11142.00	29.80	0.247	116.91	4.0	42,730
									209.80	....	116.12	....	42,440
1301	η Ori	19.4	− 2	29	3.44	B1	7.9896	5720.821	42.3	0.016	144.75	2.51	15,901
									†222.3	....	152.4	2.15	16,750
							††7.99303	*6.617	41.20	0.006	143.21	2.438	15,740
1314	ψ Ori	21.6	3	0	4.66	B2	2.52588	7916.36	184.71	0.0651	144.12	0.780	4,995
									*4.7	....	190.0	0.343	6,570
1333	χ Aur	26.2	32	7	4.88	B1	655.16	10629.78	135.52	0.171	20.53	0.56	182,300
							*655.16	10629.78	135.52	0.171	10.47	....	....
1339	δ Ori	26.9	− 0	22	2.48	B0	*5.7325	5793.756	4.9	0.096	100.12	0.589	7,850
							5.7325	8981.295	20.4	0.085	99.98	0.588	7.850
							5.732448	9806.383	359.33	0.0983	100.96	....	....
							5.732585	12391.5837	337.94	0.1066	101.53	0.6126	7,958
1349	V V Ori	28.5	− 1	14	5.37	B2	1.48540	9836.021*	....	0.00	132.37	0.358	2,704
							**120	9819	40	0.30	13.0	....	20,460
1365	θ^2 Ori	30.5	− 5	29	5.17	B1	21.029	13741.312	154.7	0.27	93.7	1.795	27,000
1366	ι Ori	30.5	− 5	59	2.87	Oe5	29.136	7587.993	113.28	0.7543	109.90	1.14	28,907
							*29.136	7587.9911	112.374	0.7415	113.681	....	30,560
							†29.136	....	....	0.00	8.38	....	3,358
1375	ζ Tau	31.7	21	5	3.00	B3p	138	5769.9	9.8	0.180	14.95	0.0455	27,900
1381	G Dor	32.4	−64	18	5.30	G5	180.8757	13108.42	333.0	0.51	22.4	0.1344	47,900
1384	β Dor	32.8	−62	33	3.81	F5p	9.84072	12702.482	5.3	0.25	15.0	0.003142	1,965
1388	125 Tau	33.5	25	50	5.00	B3	27.864	10471.607	335	0.55	25.5	0.02795	8,160
1399		35.8	− 1	11	5.00	B3	27.160	7961.465	87.02	0.765	93.04	0.6067	22,380
							*27.160	7973.791	....	0.00	10.15	....	3,791
1452	31 Cam	46.0	59	52	5.26	A0	2.9331	13440.103	359.25	0.030	76.02	0.1337	3,065
1457	136 Tau	47.0	27	35	4.54	A0	5.969	9362.52	191.44	0.0217	48.9	....	4,011
									11.4	....	71	....	....
1468	α Ori	49.8	7	23	0.92	Ma	$6^{y}0$	6693+	255	0.24	2.45	0.0029	70,000
1478	β Aur	52.2	44	56	2.07	A0p	3.960027*	7100.7324**	....	0.00	108.96	....	5,934
								....	....	....	†111.04	....	6,047
1492	2 Mon	54.3	− 9	34	5.10	A5	9.3553	9673.815	35.41	0.2083	57.1	0.1692	7,200

TABLE III—Continued.

Boss	V_o km.	Computer	Reference	Remarks
1246	+30.17	Reese	*LOB* **1**, 34, 1901	Two spectra. *Orbit of secondary. $m_1 \sin^3 i=1.19\odot$; $m_2 \sin^3 i=0.94\odot$ Visual orbit from interferometer measures. $i=41\overset{\circ}{.}08$; $\Omega=38\overset{\circ}{.}70$; $a=0\overset{''}{.}05360$. By combining these elements and spectroscopic results Merrill finds $m_1=4.2\odot$; $m_2=3.3\odot$; $a_1+a_2=$ 126,630,000 km. $\pi=0\overset{''}{.}0632$.
		Merrill	*ApJ* **56**, 40, 1922	
1250	+22.62	Plaskett	*ApJ* **30**, 26, 1909	Plaskett and Ludendorff (*AN* **183**, 9, 1909) suspect that velocity of system is variable.
1275	−14.17	Cannon	*DO* **4**, 197, 1918	Two spectra. $m_2/m_1=0.99$. Orbit of secondary.
1301	+35.5	Adams	*ApJ* **17**, 71, 1903	Two spectra. Beal, *AAS* **3**, 117, 1918, finds velocity of system variable in a period of nine to ten years. †Orbit of secondary, based on Baker's ratio of masses, *AO* **1**, 136, 1910. $m_1 \sin^3 i=11.2\odot$; $m_2 \sin^3 i=10.6\odot$; $m_2/m_1=0.95$.
	+37.02	Hnatek	*AN* **217**, 53, 1922	††Based on Adams's observations and those of 1920, Vienna. *T time of zero velocity when changing from positive to negative. H and K sharp and give constant velocity, Slipher.
1314	+12.02	Plaskett	*ApJ* **28**, 272, 1908	Two spectra. Baker, *AO* **1**, 100, 1909. $m_2/m_1=0.76$. *Orbit of secondary, based on Baker's ratio of masses. $m_1 \sin^3 i=5.53\odot$; $m_2 \sin^3 i=4.19\odot$
1333	− 0.15	Young	*DO* **4**, 1, 1916	*Orbit from H and K lines.
	+ 1.5			
1339	+22.85	Jordan	*AO* **3**, 128, 1914	K line gives constant velocity. *Least square solution of orbit by Hartmann, *ApJ* **19**, 278, 1904. Hartmann finds for $m_1=m_2$, the minimum value of $m_1+m_2=4.8\odot$
	+15.20	Jordan	*AO* **3**, 131, 1914	
	+20.15	Curtiss	*ApJ* **42**, 135, 1915	
	+21.25	Hnatek	*AN* **213**, 24, 1920	Algol variable. Stebbins, *ApJ* **42**, 133, 1915.
1349	+20.77	Daniel	*AO* **3**, 184, 1915	Algol variable. Hertzprung, *AN* **195**, 307, 1913. *Time when radial component of orbital velocity is zero and changing from negative to positive. **Provisional orbit for center of mass.
		Daniel	*AO* **3**, 185, 1915	
1365	+36.8	Struve	*ApJ* **60**, 1924	
1366	+21.34	Plaskett	*ApJ* **28**, 275, 1908	First orbit is least square solution of one by Plaskett and Harper, *ApJ* **27**, 272, 1908. *Orbit when superimposed oscillation of same period is considered. †Orbit of secondary disturbance.
	+21.53	Plaskett, Harper	*ApJ* **30**, 379, 1909	
1375	+16.4	Adams	*ApJ* **22**, 118, 1905	
1381	+ 9.85	Lunt	*CA* **10**, part 7, 22G, 1924	
1384	+ 5.3	Lunt	*CA* **10**, part 7, 32G, 1924	The elements are probably variable.
1388	+14.8	Cannon	*DO* **3**, 424, 1916	
1399	+26.12	Plaskett, Harper	*ApJ* **30**, 376, 1909	Orbit when superimposed oscillation of same period is introduced *Orbit of secondary disturbance.
1452	− 3.86	Harper	*PA* **31**, 576, 1923	Two spectra. Lick, *ASP* **34**, 168, 1922.
1457	−17.1	Cannon	*DO* **2**, 119, 1915	Two spectra. $m_2/m_1=0.7$. Orbit of secondary; based on four Lick observations.
1468	+21.3	Bottlinger	*AN* **187**, 35, 1910	Light variable. Bottlinger suspects relation between light and radial velocity variations. Lunt, *ApJ* **44**, 250, 1916, from a comparison of all published radial velocities for this star with Bottlinger's curve, concludes that the observations are not well represented.
1478	−18.1	Baker	*AO* **1**, 190, 1910	Two spectra. Several orbits have been published of this star by different observers, Rambaut, Vogel, Ludendorff, Belopolsky, and Baker. The present one is based upon all reliable data of these various observers up to 1910 and is for the epoch 1905.78. Baker finds that the period is variable. *$P=3.960027+0.000010t$ **T is the time of passage through ascending node. †Orbit of secondary. $m_1 \sin^3 i=2.21\odot$; $m_2 \sin^3 i=2.17\odot$
1492	+22.24	Elvey	*ApJ* **60**, 1924	Secondary spectrum is faintly visible at times of max. and min. vel.

TABLE III—Continued.

Boss	Star	R.A., 1900		Decl.		Mag.	Class	P.	T Jul. Day 2,410,000+	ω	e	K_1 km.	$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$	$a_1 \sin i$ 1,000 km.
1501	μ Ori	5^{h}	56^{m}9	9°	39′	4.19	A2	4.44746	13863.174	....	0	30.8	0.01349	2,000
								*18 yrs.	(1911^{y}7)	98°	0.6	98	....	300,000
1508	1 Gem		58.0	23	16	4.30	G5	9.590	11898.741	203.28	0.2065	11.74	0.0015	1,510
1515	40 Aur		59.7	38	29	5.31	A3	28.28	10468.197	178.41	0.556	51.38	....	16,550
										1.60	....	62.51	....	20,140
1525	ν Ori	6	1.9	14	47	4.40	B2	131.26	7975.16	1.58	0.599	34.09	0.2773	49,270
1593	45 Aur		13.6	53	30	5.41	F5	6.50	13634.60	357	< .05	31.9	0.0218	2,847
1607			18.0	56	20	5.50	A3	9.944	9341.776	152.9	0.081	67.19	0.3101	9,127
1609	β C Ma		18.3	−17	54	1.99	B1	0.25714	8367.700	225	0.04	9.10	0.00002	31
								†42	13070	90	0.27	4.75	0.00041	2,633
1610	δ Col		18.4	−33	23	3.98	G5	870	17305	115	0.67	11.0	0.049	97,600
1629	R T Aur		22.1	30	33	var	G0	3.7282	3.423*	95.02	0.368	17.96	0.0018	856
								3.72806	3.686*	115.30	0.428	11.97	0.0004902	555
1635	ν Gem		23.0	20	17	4.06	B5	9^{y}6	(1909^{y}75)	285	0.20	30.0	9.24	1,417,000
1646	....		25.9	32	32	5.98	A0	2.5248	11623.3637*	....	0.00†	115.6	....	4,010
												135.1	....	4,690
1690	γ Gem		31.9	16	29	1.93	A0	2175	0101.6	16.31	0.298	6.12	0.04503	174,720
....	BD 6° 1309		32.0	6	13	6.06	B0p	14.414	13031.870	181.95	0.035	206.38 †246.7	....	40,880
1773	A Car		47.7	−53	30	4.38	G5	195.32	11344.0	....	0.0	24.8	0.313	66,880
1815	ζ Gem		58.2	20	43	var	G0p	10.154	1.313*	333	0.22	13.2	0.0023	1,798
....	HD 54371	7	3.5	25	54	7.01	G0	32.8092	13071.941	82.1	0.080	27.5	0.0705	12,383
1899	29 C Ma		14.5	−24	23	4.90	Oe	4.3934	7240.248	37.64	0.156	218.44	4.58	13,035
1906	19 Lyn		14.7	55	28	5.61	B8	2.25960	9031.632	126.11	0.076	104.43	0.26	3,235
1909	R C Ma		14.9	−16	12	var	F0	1.1359514	7966.576	195.86	0.138	28.64	0.0027	443
1972	σ Pup		26.1	−43	6	3.27	K5	258	10419	350	0.2	18.0	....	62,570
								257.8	10418.6	349.3	0.17	18.55	0.164	64,800
1979	α_1 Gem		28.2	32	6	2.85	A0	2.928285	6828.057	102.52	0.01	31.76	0.0097	1,279
1979	α_2 Gem		28.2	32	6	1.99	A0	9.218826	6746.385	265.35	0.503	13.56	0.0015	1,485
2023	σ Gem		37.1	29	8	4.26	K0	19.605	5824.019	330.25	0.022	34.21	0.08125	9,220
2119	V Pup		55.4	−48	58	var	B1p	1.454475*	2778.327	72	0.08	....	....	....

TABLE III—Continued.

Boss	V_0 km.	Computer	Reference	Remarks
1501	+42.7	Frost, Struve	*ApJ* **60**, 1924	Epoch of orbit 1921.7. Frost and Struve find velocity of system variable with following values 1906.9, $V_\circ = +44.0$ km.; 1908.0, $V_\circ = +44.3$ km.; 1915.2, $V_\circ = +37.3$ km.; 1917.5, $V_\circ = +39.3$ km. *Orbit of center of mass of short period system. Close visual double, Aitken, *LOB* **8**, 93, 1914. Companim 6.6 mag. dis. = $0''.36$ in p.a. = $32^\circ.0$.
	+40.8			
1508	+19.71	Young	*DAO* **1**, 119, 1919	
1515	+16.91	Young	*DO* **4**, 95, 1917	Two spectra. Orbit of secondary. $m_1 \sin^3 i = 1.354\odot$; $m_2 \sin^3 i = 1.113\odot$
1525	+22.10	Harper	*RASC* **5**, 24, 1911	
1593	− 0.8	Harper	Unpublished	Preliminary elements.
1607	−13.74	Harper	*DO* **2**, 177, 1915	
1609	+33.06	Henroteau	*LOB* **9**, 155, 1918	Approximate elements deduced from velocity curve of March 1, 1909. Henroteau finds that the amplitude of the velocity curve changes rapidly, having a maximum of about 20 km. and a minimum of about 3 km., and that the variation is not simple periodic. The period of velocity variation will not connect all minima of different epochs, but will give either a maximum or minimum of the velocity curve. The lines change in width, with a period of variation of $0^{\mathrm{d}}.25130$. The observed phenomena are difficult to interpret on the ordinary binary hypothesis. †Approximate elements for a possible orbit of center of mass.
	+29.3	Henroteau	*DO* **8**, 41, 1922	
1610	− 5.9	Wilson, Huffer	*LOB* **10**, 16, 1918	
1629	+21.43	Duncan	*LOB* **5**, 121, 1909	Cepheid variable. *Interval after light maximum. Variation in magnitude 5.0 to 5.6. Orbit by Keiss based on observations nine years later than those of Duncan.
	+19.96	Keiss	*DetO* **3**, 132, 1917	
1635	+38.45	Harper	*DO* **4**, 279, 1919	There probably is a short period oscillation, but no satisfactory one has been found for it. H and K lines give velocitics differing from other lines.
1646	− 5.8	Joy	*ASP* **30**, 254, 1918	Two spectra. Algol variable. *Primary minimum. †Assumed. Orbit of secondary. $m_1 \sin^3 i = 2.2\odot$; $m_2 \sin^3 i = 1.9\odot$
1690	−12.28	Harper	*RASC* **6**, 185, 1912	Owing to paucity of observations near maximum of velocity curve the elements are entitled to small weight. Ludendorff, *AN* **192**, 447, 1912, calls attention to the fact that his 24 observations, Jan.–April, 1910, which should represent the maximum, give residuals from Harper's curve of 9 km. The elements obviously need revision.
....	+23.94	Plaskett	*DAO* **2**, 147, 1922	Two spectra. $(a_1+a_2) \sin i = 89750000$ km.; $m_1 \sin^3 i = 75.6\odot$; $m_2 \sin^3 i = 63.3\odot$ †Orbit of secondary.
1773	+25.4	Wilson, Huffer	*LOB* **10**, 17, 1918	Preliminary orbit.
1815	+ 6.8	Campbell	*ApJ* **13**, 93, 1901	Cepheid variable. *Interval after minimum brightness. Campbell finds residuals from elliptic curve satisfied by simple circular motion in period 3.385 with single amplitude 2.25 km. Jacobsen, *ASP* **35**, 255, 1923, finds that his 21 observations of March–May, 1923, are represented by Campbell's curve within the errors of observation. The period which best represents the two sets of observations is $10^{\mathrm{d}}.15258$.
....	+19.7	Sanford	*ApJ* **56**, 446, 1922.	
1899	−12.12	Harper	*DO* **4**, 123, 1917	
1906	+ 7.37	Harper	*DO* **4**, 235, 1918	
1909	−39.70	Jordan	*AO* **3**, 52, 1913	
1972	+88.5	Lunt	*ApJ* **44**, 261, 1916	
....	+87.3	Wilson	*LOB* **9**, 119, 1918	
1979	− 0.98	Curtis	*LOB* **4**, 58, 1906	Several orbits by Belopolsky 1896–1900. Russell finds mass of Castor (a_1 and a_2) is $6.5\odot$; $\pi = 0''.08$, *ApJ* **32**, 361, 1910. Visual orbit of Castor very uncertain.
1979	+ 6.20	Curtis	*LOB* **4**, 64, 1906	
2023	+45.80	Harper	*DO* **1**, 279, 1911	
2119	....	Miss Maury	*PA* **29**, 22, 1922	Relative orbits. $K_1+K_2 = 604$ km.; $(a_1+a_2) \sin i = 12{,}041{,}000$ km.; $(m_1+m_2) \sin^3 i = 33\odot$ Algol variable. Two spectra. *Photometric period.

TABLE III—Continued.

Boss	Star	R.A., 1900		Decl.		Mag.	Class	P.	T Jul. Day 2,410,000+	ω	e	K_1 km.	$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$	$a_1 \sin i$ 1,000 km
2179	ε Vol	8^h	7^m6	−68°	19′	4.46	B5	14.16833	9453.562*	....	0.00	66.67	0.437	12,999
2227	1 Hya		19.6	− 3	26	5.67	F5	1.562975	12650.082	123°92	0.051	30.28	0.0045	650
2285			30.5	6	58	6.04	F5	14.296	11599.474	220.80	0.276	22.74	0.015	4,300
2354	ε Hya		41.5	6	47	3.48	F8	5588	5375	90.0	0.65	8.45	....	493,000
2421	w Vel		56.3	−40	52	4.42	F8	74.1469	12728.629	90.0	0.05	17.8	0.0433	18,130
2445	κ Cnc	9	2.3	11	4	5.14	B8	6.393	6486.897	162.3	0.149	67.8	0.200	5,890
2447	75 Cnc		2.9	27	3	5.96	G5	19.4589	12426.634	252.5	0.206	20.21	0.0157	5,296
2463	c U Ma		6.4	61	50	5.23	F8	16.2382	13049.617	169.25	0.09	34.78	0.07	7,730
2473	a Car		8.4	−58	33	3.56	B3	6.744	6533.81	115.84	0.18	21.5	0.0066	1,960
2484	....		10.8	47	14	5.70	A0	15.986	9408.027	355.2	0.504	63.34	....	12,026
										175.2	....	73.64	....	13,981
2490	23 Hya		11.7	− 5	56	5.40	K0	914.0	11263	57.0	0.36	11.7	0.1235	137,190
2526	κ Vel		19.0	−54	35	2.63	B3	116.65	6459.00	96.23	0.19	46.5	1.15	73,200
....	S Ant		27.9	−28	11	var	F0	0.64833872	....	....	0*	81	....	722
												†148	....	1,320
2602	ο Leo		35.8	10	21	3.76	F5	14.4980	4656.477*	....	<0.02	54.0	0.238	10,775
												†63.1	0.378	12,571
....	W U Ma		36.7	56	25	var	G0	0.3336392*	....	....	0.00†	134	....	610
												††188	....	860
2628	l Car		42.5	−62	3	var	G0	35.523	7636.76	99.5	0.36	18.86	0.0211	8,593
2651	m Vel		47.8	−46	5	4.56	G5	329.2	....	....	....	15.8	....	....
2665	19 L Mi		51.6	41	32	5.19	F5	9.28	13500.50	60	0.15	17.5	0.005	....
2754	30 U Ma	10	16.9	66	4	4.92	A0	11.5832	8468.212	171.9	0.381	34.07	0.03759	5,020
2830	p Vel		33.1	−47	42	4.06	F2	10.210955	10259.381	184.62	0.541	42.34	....	4,981
										*4.62	....	52	....	6,107
2900	ω U Ma		48.2	43	43	4.84	A0	15.8401	7991.101	11.95	0.264	20.64	....	4,336
....	HD 96511	11	2.2	82	17	7.1	G0	18.8922	13154.071	332.97	0.282	40.1	0.1111	9,975
2984	ξ U Ma		12.9	32	6	4.41	G0	665	5252.7	322.65	0.41	7.0	0.018	58,300
2987	55 U Ma		13.7	38	44	4.78	A2	2.5	11412.762	173.4	0.11	38.5	....	1,315
										353.4	....	54.5	....	1,862
3098	93 Leo		42.8	20	46	4.54	F8	71.70	8088.405	270.81	0.008	26.54	0.139	26,170
								71.70	8029.255	331.15	0.082	23.66	0.09764	23,250
3138	31 Crv		55.7	−19	6	5.28	B3	1.50307	10917.573	185.08	0.078	118.19	0.25	2,435
3146	θ^1 Cru		57.9	−62	45	4.48	A5	24.483	807.257	354.83	0.629	48.2	0.1338	12,600
3182	4 Dra	12	7.5	78	10	5.12	A5	1.27100	10685.265*	....	0.00	63.2	0.0333	1,104
3210	η Vir		14.8	− 0	7	4.00	A0	71.9	6206.93	180.0	0.254	26.8	0.130	25,290
								71.9	7643.50	185.0	0.40	(27.6)*	0.126	25,750
....	HD 107760		17.9	73	48	8.2	G5	5.41454	12853.120*	....	0.00	64.9	....	4,833
												74.0	....	5,510
3281	κ Dra		29.2	70	20	3.88	B5p	8.986	10609.02	326	0.23	15.7	0.00325	1,890

TABLE III—Continued.

Boss	V₀ km.	Computer	Reference	Remarks
2179	+ 9.68	Sanford	*LOB* **8**, 130, 1914	*T epoch of perihelion passage of primary.
2227	+71.3	Sanford	*ApJ* **55**, 30, 1922	
2285	+24.23	Joy, Abetti	*ApJ* **50**, 391, 1919	
2354	+36.79	Aitken	*ASP* **24**, 218, 1912	Visual orbit, Aitken, *ASP* **24**, 216, 1912, $P=15^{\mathrm{y}}.3$; $e=0.65$; $T=1900.97$; $\omega=270^{\circ}.0$; $i=49^{\circ}.95$; $\Omega=104^{\circ}.4$; $a=0''.23$; distance between components$=1{,}359{,}000{,}000$ km.; $\pi=0''.025$; $m_1=1.75\odot$; $m_2=1.58\odot$
2421	− 7.4	Lunt	*CA* **10**, 37G, 1924	
2445	+26.3	Ichinohe	*ApJ* **25**, 318, 1907	Two spectra. The elements refer to brighter component.
2447	+12.3	Sanford	*ApJ* **55**, 35, 1922	Spectrum G1.
2463	−14.99	Young	*DAO* **2**, 205, 1923	
2473	+23.3	Curtis	*LOB* **4**, 154, 1907	
2484	−13.11	Harper	*DO* **3**, 405, 1916	Two spectra. Orbit of secondary. $m_1 \sin^3 i=1.48\odot$; $m_2 \sin^3 i=1.27\odot$
2490	− 5.0	Lunt	Unpublished	Preliminary orbit.
2526	+21.9	Curtis	*LOB* **4**, 156, 1907	
....	− 5.0	Joy	*PA* **29**, 630, 1921	Two spectra. *Assumed. †Orbit of secondary. $m_1 \sin^3 i=0.52\odot$; $m_2 \sin^3 i=0.29\odot$ Joy shows that it is an Algol variable. From photometric and spectroscopic elements. $m_1=0.75\odot$; $m_2=0.42\odot$; $d_1=0.31D_{\circ}$; $d_2=0.38D_{\circ}$; π (surface brightness$=4\times$Sun) $=0''.016$.
2602	+27.07	Plummer	*LOB* **5**, 21, 1908	Two spectra. *Time when observed velocity of each component is equal to the velocity of the system, with principal component between the center of mass and the solar system. †Orbit of secondary. $m_1 \sin^3 i=1.302\odot$; $m_2 \sin^3 i=1.116\odot$; $m_2/m_1=0.86$. Also orbit by Zurhellen. *AN* **173**, 353, 1907.
....	− 5	Adams	*ApJ* **49**, 189, 1919	Two spectra. Algol variable. *Light period. †Assumed. ††Orbit of secondary. $m_1 \sin^3 i=0.67\odot$; $m_2 \sin^3 i=0.48\odot$; $m_2/m_1=0.71$. Using Shapley's photometric orbit (uniform solution) and spectroscopic elements ($i=77^{\circ}.6$); $m_1=0.69\odot$; $m_2=0.49\odot$; $d_1=2.8\ D_{\circ}$; $d_2=1.9\ D_{\circ}$. Densities highest known in any stellar system.
2628	+ 4.10	Wilson, Huffer	*PA* **29**, 85, 1921	Cepheid variable. Spectrum varies F8 to G5. Albrecht *PA* **27**, 520, 1919.
2651	+10.8	Lunt	Unpublished	Preliminary orbit.
2665	−10.3	Harper	Unpublished	Preliminary elements.
2754	−0.10	Schlesinger	*AO* **2**, 149, 1912	Rediscussion of material used in orbit by Baker, *AO* **2**, 29, 1910, but with secondary oscillation removed. K line gives orbit with simple elliptic motion.
2830	+19.25	Sanford	*LOB* **9**, 182, 1918	Two spectra. Visual double. *Orbit of secondary. $m_1 \sin^3 i=0.281\odot$; $m_2 \sin^3 i=0.235\odot$
2900	−18.45	Parker	*RASC* **5**, 382, 1911	Two spectra. From 3 measures of secondary, Parker derives $K_2=120$ km.; $m_2/m_1=0.17$.
....	−46.75	Sanford	*ApJ* **59**, 360, 1924	
2984	−16.4	Abetti	*Soc. Degli Spct. Ital.* **8**, Ser. 2ᵃ, 113, 1919.	The brighter visual component. Period of visual binary $60^{\mathrm{y}}.8$. Nörlund finds a perturbation of period $1^{\mathrm{y}}.80$ in the orbit of the visual binary. *AN* **170**, 123, 1905.
2987	− 3	Henroteau	*PA* **27**, 29, 1919	Two spectra. Approximate orbit. Orbit of secondary. $m_1 \sin^3 i=0.123\odot$; $m_2 \sin^3 i=0.085\odot$
3098	+ 0.17	Cannon	*RASC* **4**, 458, 1910	Based on spectro-comparator measures.
	− 0.20	Cannon	*RASC* **4**, 455, 1910	Derived from micrometer measures of the same plates.
3138	+ 1.70	Cannon	*DO* **4**, 125, 1917	
3146	− 2.04	Lunt	*CA* **10**, 17G, 1924	
3182	+ 0.3	Lee	*ApJ* **43**, 320, 1916	*Time of maximum velocity of recession.
3210	− 0.4	Ichinohe	*ApJ* **26**, 282, 1907	Two spectra; faint companion with non-elliptic curve suggesting third component, gives V₀ = +30 km. *Estimated from published curve. $m_2/m_1=0.7$, Schlesinger and Baker, *AO* **1**, 145, 1910.
	+ 2.2	Harper	*ApJ* **27**, 160, 1908	
....	−97.4	Sanford	*ApJ* **56**, 452, 1922	Two spectra. *T is time of smallest negative velocity of primary. Orbit of secondary. $m_1 \sin^3 i=0.803\odot$; $m_2 \sin^3 i=0.704\odot$
3281	− 7.2	Baker	*Det O* **3**, 33, 1920	Elements from Hβ emission and broad He, 4471 absorption. Narrow H absorption lines and K lines do not share in short period oscillation but slowly change position.

TABLE III—Continued.

Boss	Star	R.A., 1900		Decl.		Mag.	Class	P.	T Jul. Day 2,410,000+	ω	e	K_1 km.	$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$	$a_1 \sin i$ 1,000 km.
3323	32 Vir	12^h	40^m7	8°	$13'$	5.24	A5	38.3	10573.455	$223^{\circ}35$	0.072	40.99	....	21,530
										43.35	....	80		
3363	ϵ U Ma		49.6	56	30	1.68	A0p	4^y15	(1907^y40)	55.8	0.31	3.5	0.0058	69,360
3371	α^2 C Vn		51.4	38	51	2.90	A0p	*5.50	3.84†	110	0.3	21.5	0.00493	1,500
3393	ξ^2 Cen	13	1.1	−49	22	4.40	B3	8.024	2266.81	287	0.5	....	....	....
....	RS C Vn		6.0	36	28	var	F8	4.797851*	....	....	0	286	....	5,700
3474	ζ^1 U Ma btr.		19.9	55	27	2.40	A2p	20.53644	9477.744	103.96	0.535	69.22	....	16,400
												*68.83	....	16,400
3476	α Vir		19.9	−10	38	1.21	B2	4.01416*	7955.846	328	0.10	126.1	....	6,930
										†148	....	207.8	....	11,400
3511	....		30.3	37	42	4.96	F0	1.61100	7018.020	199.05	0.054	10.06	0.0002	222
3564	ν Cen		43.5	−41	11	3.53	B2	2.62516	10301.39	....	0.00	20.63	0.00239	745
3586	h Cen		47.5	−31	26	4.76	B5	6.927	8733.25	147.23	0.23	21.4	0.0065	1,984
3596	η Boo		49.9	18	54	2.80	G0	497.1	8240.60	315.20	0.236	8.692	0.0311	57,735
3626	α Dra	14	1.7	64	51	3.64	A0p	51.38	7403.284	19.04	0.384	46.25	0.416	30,173
3635	d Boo		5.8	25	34	4.82	F5	9.6045	7679.523	273	0.169	68.40	....	8,904
										*93	....	72.05	....	9,380
3644	....		8.5	− 0	22	5.81	F5	2.6960	12744.103*	....	0.00	24.34	0.00404	902
3673	A Boo		13.8	35	58	4.83	K0	211.95	10561.18	223.42	0.54	18.02	0.076	44,000
3700	τ^2 Lup		19.8	−44	56	4.49	F5	3043	....	....	....	12.7	....	....
3793	39 Boo		46.3	49	8	6.8	F5	12.822	12379.490	97.05	0.394	58.31	....	9,450
										277.05	....	72.19	....	11,700
3825	δ Lib		55.6	− 8	7	var	A0	2.32735†	1.89*	29.2	0.054	76.5	0.11	2,450
3827	....		56.0	66	20	4.86	Mb	750	12065.0	....	0	6.67	0.023	68,800
....	R Tr A	15	10.8	−66	8	var	F5–G5	3.3891	8407.179	58	0.17	16.0	0.00138	735
....	U Cr B		14.1	32	1	var	B8	3.4522269†	....	....	0*	69.5	....	11,940
3928	γ U Mi		20.9	72	11	3.14	A2	0.108449	13204.73	160.0	0.09	14	0.00003	35
3940	β Cr B		23.7	29	27	3.72	F0p	40.9	8739.29	240	0.4	3.10	0.0001	1,600
								†490.8	8804.4*	....	0.0	2.4	0.705	....
3961	α Cr B		30.5	27	3	2.31	A0	17.36	7742.55	312.2	0.387	34.93	0.0602	7,671
								*17.355	7725.054	303.68	0.277	32.97	0.0573	7,560
								†17.355	....	316	0.35	33	....	....
....	T W Dra		32.4	64	14	var	A5	2.80654*	0.019†	90	0.0536	65.78	0.0826	2,535

TABLE III—Continued.

Boss	V_o km.	Computer	Reference	Remarks
3323	− 8.89	Cannon	*DO* **2**, 383, 1915	Two spectra. Orbit of secondary. $m_2/m_1=0.51$.
3363	−12.9	Ludendorff	*AN* **195**, 370, 1913	From component of Mg 4481, $m_2/m_1=0.15$; $m_1 \sin^3 i=2.3\odot$; $m_2 \sin^3 i=0.3\odot$
3371	+ 1	Belopolsky	*AN* **196**, 1, 1913	Light variable in period of 5.50 days. Guthnick and Prager, *Ver. K. Sternw. Ber. Babelsburg* 1, 44, 1914. *Orbit from λ4205. †After max. intensity of λ4205. Belopolsky finds two groups of lines which vary in intensity in period of 5.50 days. When lines of one group are strong, those of other group are weak and vice versa. Keiss, *DetO* **3**, 106, 1919, confirms Belopolsky's results. See papers by Belopolsky and Keiss for suggested explanation of phenomenon.
3393	....	Miss Maury	*PA* **29**, 636, 1921	Relative orbits. $K_1+K_2=312$ km.; $(a_1+a_2) \sin i=29{,}800{,}000$ km.; $(m_1+m_2) \sin^3 i=16.4\odot$
....	− 9	Joy	*ASP* **34**, 221, 1922	Algol variable. Two spectra; brighter star F3, fainter star K0. Preliminary orbit. *Light period, Sitterly. $K_1=K_2$; $a_1 \sin i=a_2 \sin i$; $m_1 \sin^3 i=m_2 \sin^3 i=1.3\odot$
3474	− 9.64	Hadley	*DetO* **2**, 101, 1915	Orbits by Vogel, *ApJ* **13**, 328, 1901; Ludendorff, *AN* **180**, 276, 1909; Hnatek, *AN* **209**, 49, 1919. The present one is from a discussion of Ludendorff's and Hadley's observations. Two spectra. *Orbit of secondary. $m_1 \sin^3 i=1.70\odot$; $m_2 \sin^3 i=1.62\odot$
3476	+ 1.6	Baker	*AO* **1**, 72, 1909	Two spectra. Eclipsing variable. Stebbins, *ApJ* **39**, 475, 1914. *T is instant when velocity equals that of center of mass. Earlier orbit by Vogel, *Ptm* **7**, 136, 1892. †Orbit of secondary. $m_1 \sin^3 i=9.6\odot$; $m_2 \sin^3 i=5.8\odot$
3511	+ 6.64	Harper	*DO* **4**, 232, 1918	
3564	+ 9.05	Wilson	*LOB* **8**, 131, 1914	
3586	+ 5.2	Paddock	*LOB* **9**, 45, 1916	
3596	− 0.234	Harper	*RASC* **4**, 194, 1910	
3626	−17.03	Harper	*RASC* **4**, 92, 1910	Several orbits by Plaskett and Harper. *Rep. Chief Astron.* (Can.), 1907, *App.* **3**, p. 146, and *RASC* **1**, 244, 1907.
3635	+ 9.80	Harper	*DO* **1**, 329, 1911	Two spectra. $m_1 \sin^3 i=1.36\odot$; $m_2 \sin^3 i=1.29\odot$ *Orbit of secondary.
3644	+17.60	Duncan	*ApJ* **54**, 226, 1921	*Epoch of maximum positive velocity.
3673	−25.62	Young	*DO* **3**, 107, 1915.	
3700	− 2.1	Lunt	Unpublished	Approximate.
3793	−28.23	Harper	*DAO* **2**, 167, 1922	Two spectra. Orbit of secondary. $m_1 \sin^3 i=1.27\odot$; $m_2 \sin^3 i=1.03\odot$
3825	−45.0	Schlesinger	*AO* **1**, 126, 1910	Algol variable. *Interval after light minimum. †Apparent period. True period $=2.32770$ days. From photometric and spectroscopic data Schlesinger finds $(i=81^\circ\!.5)$, $m_1+m_2=1.5\odot$; assuming density of two bodies equal, $d=0.026D_o$; $m_1=0.87\odot$; $m_2=0.63\odot$; $m_2/m_1=0.70$.
3827	+ 6.85	Young	*DAO*, 1924	Spectral class M6.
....	−18.9	Hellerich	*AN* **219**, 169, 1923	Cepheid variable. Preliminary orbit from 13 observations by Paddock. Insufficient observations at maximum of velocity curve.
....	− 7.5	Plaskett	*DAO* **1**, 189, 1920	Eclipsing variable. Mag. 7.9–9.1. Two spectra. *Assumed. $(m_1+m_2) \sin^3 i=5.7\odot$; $m_2/m_1=0.38$. †Photometric period. From Shapley's photometric orbit $(i=81^\circ\!.4)$ $m_1=4.27\odot$; $m_2=1.63\odot$; $d_1=0.175\ D_o$; $d_2=0.015\ D_o$.
3928	− 2	Struve	*PA* **31**, 90, 1923	Range and shape of velocity curve varies. Light variable, Gutnick.
3940	−21.28	Cannon	*DO* **1**, 405, 1912	Probably triple system. †Approximate elements of long period oscillation, assumed to be a sine curve. *Time when "up-curve" crosses zero line.
3961	+ 0.36	Jordan	*AO* **1**, 89, 1909	Eclipsing variable. Stebbins, *ApJ* **39**, 478, 1914.
	+ 0.498	Cannon	*RASC* **3**, 421, 1909	*Elements depend upon use of $H\beta$, $H\gamma$, $H\delta$, and K lines.
	+ 6.69	Cannon	*RASC* **3**, 152, 1909	†Mg 4481 alone gives these elements.
....	− 0.34	Plaskett	*DAO* **1**, 147, 1919	Eclipsing variable; Mag. 7.8–9.8. *Photometric period. †From primary minimum.

TABLE III—Continued.

Boss	Star	R.A., 1900		Decl.		Mag.	Class	P.	T Jul. Day 2,410,000+	ω	e	K_1 km.	$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$	$a_1 \sin i$ 1,000 km.
4008	A Ser	15^h	40^m9	− 1°	29′	5.37	B8	38.95	9528.597	208°46	0.773	50.52	0.133	17,170
4086	β Sco		59.6	−19	32	2.90	B1	6.8283	9163.923	20.09	0.270	125.66	....	11,360
										*200.09	....	197	....	17,800
								6.8284	8126.000	20	0.27	126	....	10,990
										*200	....	126	....	14,450
4090	θ Dra	16	0	58	50	4.11	F8	3.0708	5368.962	126.112	0.014	23.47	0.0041	990
....	H D 144426		0.8	8	22	6.14	A2	8.855	1846.704	265.41	0.376	31.62	0.023	3,568
....	H D 144515		1.2	10	57	8.5	G5	4.28503	12418.0522	82.49	0.089	38.1	0.0244	2,238
4158	σ Sco		15.1	−25	21	3.08	B1	0.246829	10671.800	110	0.05	39.0	0.0014	129
								0.246834	11687.972	15	0.11	41.2	0.00176	138
								†34.08	11715.35	270	0.33	33	0.107	14,600
4166	ζ Tr A		17.7	−69	52	4.93	G0	13.7155	13629.682	270.0	0.00	7.9	0.00070	1,490
4174	ι Tr A		18.7	−63	50	5.30	F0	39.888	13275.7	82.0	0.33	39.2	0.2099	19,835
4193	α Sco		23.3	−26	13	1.22	Map	5^y80	6673.582	289	0.20	2.12	0.002	60,490
4204	β Her		25.9	21	42	2.81	K0	410.575	5500.374	24.6	0.550	12.782	0.0519	60,280
....	HD 149632		30.9	17	15	6.27	A0	10.56	12422.236	4.12	0.430	62.41	....	8,180
										184.12	....	101.36	....	13,280
4277	μ^1 Sco		45.1	−37	53	3.09	B3p	1.44627	2375.571	190	0.05	....	....	....
4322	h Dra		55.5	65	17	4.82	F5	51.710	4813.75	329.32	0.128	17.96	0.03	12,625
4327	ε U Mi		56.2	82	12	4.40	G5	39.482	8005.75	359.46	0.0113	39.954	0.2614	17,346
4328	ε Her		56.5	31	4	3.92	A0	4.0235	8086.253	*180°	0.023	70.39	....	3,890
										*0	....	†112.1	....	6,200
....	HD 155375	17	6.1	12	35	6.46	A0	23.245	11780.290	129.85	0.427	27.67	0.038	7,997
4374	α Her ftr.		10.1	14	30	5.39	F9	51.590	12468.581	27.89	0.028	29.64	0.1395	2,103
....	U Oph		11.4	1	19	var	B8	1.6773476	....	....	*0.00	179.8	....	4,147
												†204.6	....	4,718
4388	u Her		13.6	33	12	var	B3	2.05102	8125.80	66.15	0.053	99.50	....	2,800
										*246.15	....	253	....	7,120
....	TX Her		15.4	42	0	var	A5	2.059786	0.0415*	....	0.0	121.01	....	7,397
												140.16		
4423			21.3	− 5	0	4.61	F0	26.2742	8411.524	14.48	0.491	47.49	....	14,950
										194.48	....	50.67	....	....
....	HD 159082		27.6	12	0	6.18	B9	6.7984	12878.154	116.26	0.069	50.18	0.0886	4,680
4462	ξ Ser		31.9	−15	20	3.64	A5	2.292285	9209.618*	....	0	19.35	0.00172	610
4483	ω Dra		37.5	68	48	4.87	F5	5.27968	7415.491	333.76	0.011	36.26	0.0261	2,632
4493	X Sgr		41.3	−27	48	var	F8	7.01185	6723.05	93.65	0.40	15.2	0.0016	1,334
4507	....		44.4	47	39	6.34	A0	2.82424	12106.713	30	0.017	60.15	0.06	2,336
....	Y Oph		47.3	− 6	7	var	G0p	17.1207	2.6*	209.2	0.10	8.5	0.0011	1,999
									2.41*	201.7	0.163	7.70	....	1,790

TABLE III—Continued.

Boss	V_o km.	Computer	Reference	Remarks
4008	−11.63	Jordan	*AO* **3**, 157, 1915	
4086	−11.0	Daniel, Schlesinger	*AO* **2**, 135, 1912	Brightest of visual triple. Two spectra. *Orbit of secondary. Daniel and Schlesinger, $m_1 \sin^3 i = 13.0 \odot$; $m_2 \sin^3 i = 8.3 \odot$; Duncan, $m_1 \sin^3 i = 9.0 \odot$; $m_2 \sin^3 i = 6.8 \odot$. Slipher and Duncan find calcium lines constant, $V = -16.6$ km. Daniel and Schlesinger find K line may show oscillation of small amplitude in same period as brighter component, but if constant $V = -8.5$. May be eclipsing variable, Stebbins, *ApJ* **39**, 481, 1914.
	− 8.0	Duncan	*LowOB* **2**, 21, 1912	
4090	− 8.36	Curtis	*LOB* **4**, 157, 1907	
....	−21.54	J. W. Campbell	*DAO* **1**, 315, 1921	
....	−60.6	Sanford	*ApJ* **53**, 201, 1921	
4158	+ 2.0	Selga	*RSA* (Spain and Amer.) **6**, 41, 1916	Variation in velocity of system suspected by Selga and confirmed by Henroteau. †Elements of long period variation. Henroteau, *DO* **5**, 303, 1921, and *DO* **8**, 45, 1922, finds long period = 32.25 days for observations 1918–1922, but that Selga's observations of 1915 fit better the period 34.08 days and that the amplitude of long period curve is variable. The period of short period variation is found to be variable. See his papers for discussion of results.
	var	Henroteau	*LOB* **9**, 176, 1918	
	− 3.2	Henroteau	*LOB* **9**, 177, 1918	
4166	+ 7.4*	Lunt	Unpublished	Provisional elements. *Mean velocity.
4174	− 5.2*	Lunt	Unpublished	Provisional elements. *Mean velocity.
4193	− 3.09	Halm	*CA* **10**, part 3, 56c, 1909	The Cape observations 1908–1912 indicate that the period is much longer than $5^{\mathrm{y}}8$, Lunt *ApJ* **44**, 250, 1916.
4204	−25.52	Plummer	*LOB* **5**, 25, 1908	
....	− 9.88	Young	*DAO* **1**, 233, 1920	Two spectra. Orbit of secondary. $m_1 \sin^3 i = 2.19 \odot$; $m_2 \sin^3 i = 1.35 \odot$
4277	....	Miss Maury	*PA* **29**, 22, 1921	Relative orbits. $K_1 + K_2 = 480$ km.; $(a_1 + a_2) \sin i = 9{,}534{,}000$ km.; $(m_1 + m_2) \sin^3 i = 16.5 \odot$
4322	−22.59	Harper	*DO* **4**, 243, 1918	
4327	−11.398	Plaskett	*RASC* **4**, 464, 1910	
4328	−24.03	Baker	*AO* **2**, 21, 1910	Two spectra. Earlier orbit Harper, *RASC* **4**, 302, 1910, derived from blended lines. *Assumed. †Orbit of secondary. $m_1 \sin^3 i = 1.6 \odot$; $m_2 \sin^3 i = 1.0 \odot$
....	+ 3.51	Harper	*DAO* **1**, 200, 1920	
4374	−37.2	Sanford	*ApJ* **53**, 214, 1921	Companion of α Herculis.
....	−11.5	Plaskett	*DAO* **1**, 137, 1919	Orbit of brighter component of eclipsing variable. Mag. 6.0–6.7. *Assumed. †Orbit of fainter component. $(m_1 + m_2) \sin^3 i = 9.890 \odot$; $m_2/m_1 = 0.88$. Shapley's photometric data (uniform solution) gives $(i = 85^\circ.7)$ $m_1 = 5.31 \odot$; $m_2 = 4.66$; $d_1 = 0.20 D_o$; $d_2 = 0.18 D_o$. For darkened solution $(i = 83^\circ.97)$, $m_1 = 5.36 \odot$; $m_2 = 4.71 \odot$; $d_1 = 0.18\ D_o$; $d_2 = 0.16\ D_o$.
4338	−21.16	Baker	*AO* **1**, 82, 1909	Two spectra. Eclipsing variable. Mag. 4.6–5.4. *Orbit of secondary. $m_1 \sin^3 i = 6.8 \odot$; $m_2 \sin^3 i = 2.6 \odot$ From photometric and spectroscopic data, *AO* **2**, 51, 1910, Schlesinger and Baker find $(i = 75^\circ)$, $m_1 = 7.5 \odot$; $m_2 = 2.9 \odot$; $d_1 = 0.37\ D_o$; $d_2 = 0.14\ D_o$; distance between centers of stars 10,200,000 km.
....	− 6.38	Plaskett	*DAO* **1**, 209, 1920	Eclipsing variable. Two spectra. *After principal minimum. $(m_1 + m_2) \sin^3 i = 3.78 \odot$; $m_2/m_1 = 0.86$. From Shapley's photometric orbit (darkened) $i = 86^\circ.27$, then $m_1 = 2.04 \odot$; $m_2 = 1.77 \odot$; $d_1 = 0.87\ D_o$; $d_2 = 0.75\ D_o$. Separations of two stars = 7,413,000 km.; radius of each star 927,000 km.
4423	+ 0.44	Parker	*DO* **2**, 348, 1915	Two spectra. Orbit of secondary. $m_2/m_1 = 0.96$.
....	−12.79	J. W. Campbell	*DAO* **2**, 162, 1922	
4462	−42.77	Young	*LOB* **6**, 161, 1911	*Epoch of perihelion.
4483	−13.68	Turner	*LOB* **4**, 164, 1907	
4493	−13.50	Moore	*LOB* **5**, 111, 1909	Cepheid variable. Mag. 4.4–5.0. Spectrum varies F1 to G5, Shapley.
4507	−27.30	Harper	*DAO* **1**, 128, 1919	
....	− 5.0	Albrecht	*LOB* **4**, 132, 1907	Cepheid variable. Mag. 6.2–7.0. Type F5–G3, Shapley, *ApJ* **44**, 274, 1916. *Interval after light maximum. Orbit by Miss Udick is least square solution of Albrecht's data. Orbit, also by Zurhellen, from same data. *AN* **177**, 330, 1908.
	− 5.10	Miss Udick	*AO* **2**, 153, 1912	

TABLE III—Continued.

Boss	Star	R.A., 1900		Decl.		Mag.	Class	P.	T Jul. Day 2,410,000+	ω	e	K_1 km.	$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$	$a_1 \sin i$. 1,000 km.
....	Z Her	17^{h}	$53^{m}6$	15°	9′	var	F5p	3.992775*	....	....	0.00†	88.2	....	4,800
												††101.8	....	5,600
4564	W Sgr		58.6	−29	35	var	F8p	7.59460†	6.20*	70°0	0.320	19.5	0.00499	1,930
								††3.80	....	....	0.0	4.8		
4602	40 Dra	18	7.5	79	59	6.18	F5	10.5217	11764.6481	256.76	0.314	46.16	....	6.341
										76.76	....	51.50	....	7,074
4604	μ Sgr		7.8	−21	5	4.01	B8p	180.2	4968.4	74.70	0.441	64.5	3.63	143,500
								180.2	7495.64	79.13	0.447	66.82	4.0	148,110
4622	....		12.9	56	33	6.41	F0	2.0476	12147.630	195.10	0.039	105.09	....	2,957
										15.10	....	108.12	....	3,042
4632	Y Sgr		15.5	−18	54	var	F5p	†5.773268	4.51*	43.0	0.21	19.3	0.004	1,500
								††5.773268	5.05*	74.5	0.42	20.6	0.003	1,354
4643	108 Her		17.1	29	48	5.54	A2	5.51460	9551.742*	....	0.00	70.1	....	5,320
												†101.7	....	7,710
4669	....		22.1	29	46	5.71	A^2	9.6120	12048.711	326.43	0.468	28.49	0.016	3,330
4672	χ Dra		22.9	72	41	3.69	F8	281.8	4864.3	119.0	0.423	17.95	0.126	63,000
....	RX Her		26.0	12	30	var	A0	1.7785740	9658.5882*	....	0.00	106	....	2,599
												104	....	2,540
												†111	....	2,710
4752	ζ^1 Lyr		41.3	37	30	4.29	A3	4.29991	8109.722*	....	0.00	51.24	0.0601	3,030
4756	β Sct		41.9	− 4	51	4.47	G0	834	12480.9	33.9	0.35	16.65	0.33	178,000
....	205 Dra		45.0	49	19	7.18	F2	3.76468	12159.7691*	....	0.00	97.7	....	5,058
							A					98.3	....	5,089
4776	β Lyr		46.4	33	15	var	B8p	12.91	....	263.4	0.07	181.0	7.89	32,040
										83.4	....	89.3	0.95	15,800
								12.91	2368.85	259.3	0.11	194.6	9.71	34,339
										79.3	....	89.7	0.95	15,836
								12.9194	9.867*	0.15	0.018	184.40	8.41	32,750
										†180.15	....	75.0	....	13,300
								12.922	8.541*	325.05	0.014	183.71	8.32	32,639
4788	50 Dra		49.6	75	19	5.37	A0	4.1175	10293.519	107.6	0.012	79.12	....	4,480
										287.6	....	83.90	....	4,751
4790	ο Dra		49.7	59	16	4.78	K0	138.420	9258.16	274.31	0.114	23.46	0.183	28,030
4794	δ^1 Lyr		50.2	36	51	5.51	B3	88.112	9220.727	204.55	0.28	33.68	0.309	39,220
4797	113 Her		50.5	22	31	4.56	G0	245.3	9805.0	169.5	0.12	16.0	0.102	53,580
4864	18 Aql	19	2.3	10	55	5.10	B8	1.30226	8157.502*	....	0.00	27.59	0.0028	494
4870	....		3.0	41	16	6.15	B3	1.03088	11735.6468	20.02	0.015	12.12	0.0001905	172

TABLE III—Continued.

Boss	V_o km.	Computer	Reference	Remarks
....	−46.5	Adams, Joy	*ApJ* **49**, 194, 1919	Eclipsing variable. *Photometric period. †Assumed. Two spectra. ††Orbit of secondary, $m_1 \sin^3 i=1.5\odot$; $m_2 \sin^3 i=1.3\odot$; $m_2/m_1=0.86$. From Shapley's photometric orbit (darkened) $i=82°$; $m_1=1.6\odot$; $m_2=1.3\odot$; $d_1=0.3\ D_o$; $d_2=0.04 D_o$; radius of bright star = 1,230,000 km.; radius of secondary = 2,290,000 km.
4564	−28.6	Curtiss	*LOB* **3**, 36, 1904	Cepheid variable. Mag. 4.3–5.1. Type A8–G2, Shapley, *ApJ* **44**, 274, 1916. *Interval after light maximum. †Apparent period. True period = 7.59532 days. ††Curtis finds residuals from elliptic curve satisfied by simple circular motion of period equal to half the principal period and single amplitude 4.8 km. See further discussion by Curtiss, *DetO* **1**, 104, 1913.
4602	+ 2.93	Boothroyd	*DAO* **1**, 245, 1920	Two spectra. Orbit of secondary. $m_1 \sin^3 i=0.457\odot$; $m_2 \sin^3 i=0.413\odot$
4604	− 7	Ichinohe	*ApJ* **26**, 161, 1907	Kohl's orbit based upon remeasures of spectrograms used by Ichinohe.
	− 8.23	Kohl	*AN* **219**, 213, 1923	
4622	−8.51	Harper	*DAO* **1**, 312, 1921	Two spectra. Orbit of secondary. $m_1 \sin^3 i=1.043\odot$; $m_2 \sin^3 i=1.013\odot$
4632	+ 3.6	Duncan	*ApJ* **56**, 340, 1922	Cepheid variable. Spectrum varies F4–G4. *Interval after light maximum. Period is photometric by Hellerich. †Least square solution of 1908 observations. *LOB* **5**, 82, 1909. ††Mt. Wilson observations 1922. V_o and *e* vary.
	− 5.9	Duncan	*ApJ* **56**, 340, 1922	
4643	−20.2	Daniel, Miss Jenkins	*AO* **3**, 152, 1914	Two spectra. †Orbit of secondary, $m_1 \sin^3 i=1.72\odot$; $m_2 \sin^3 i=1.18\odot$ *Time when radial velocity of principal star is decreasing and equal to that of system. Approximate orbit by Ludendorff, *AN* **197**, 218, 1913.
4669	+ 7.54	Young	*DAO* **1**, 134, 1919	
4672	+32.38	Wright	*ApJ* **11**, 133, 1900	
....	−18.5	Shapley	*ApJ* **40**, 413, 1914	Algol variable. Mag. 7.0–7.6. Two spectra. *Primary minimum. Shapley's orbit based on 3 Yerkes spectrograms and known photometric elements; *e* assumed; $K_1=K_2$; $m_1=m_2$; $m \sin^3 i=0.88\odot$ Baker's and Miss Cummings' orbit based on 2 Yerkes observations and Shapley's period and epoch. †Orbit of secondary. $m_1 \sin^3 i=0.94\odot$; $m_2 \sin^3 i=0.89\odot$ From photometric orbit (darkened) and spectroscopic data they find $m_1=0.96\odot$; $m_2=0.91\odot$; $d_1=0.24\ D_o$; $d_2=0.22\ D_o$.
	−19.5	Baker, Miss Cummings	*LawsOB* **2**, 154, 1916	
4752	−25.97	Jordan	*AO* **1**, 118, 1909	*T is time of maximum positive velocity.
4756	−21.9	Young	*DAO*, 1924	Spectral class G6.
....	−18.8	Sanford	*ApJ* **53**, 217, 1921	Two spectra. *Epoch of maximum positive velocity for star 1. Orbit of secondary. $m_1 \sin^3 i=1.48\odot$; $m_2 \sin^3 i=1.47\odot$
4776	−14.8	Belopolsky	*ApJ* **6**, 328, 1897	β Lyrae variable (prototype). Important spectrographic observations by Vogel, Belopolsky, and others. Myers' orbit based on Belopolsky's observations. From Argelander's photometric observations and spectroscopic orbit Myers estimates $r_1=19{,}545{,}000$ km.; $r_2=25{,}900{,}000$ km.; $a_1+a_2=50{,}175{,}000$ km.; $e=0.018$; $m_1=9.65\odot$; $m_2=20.91\odot$; $m_2/m_1=0.45$; $d=0.0006\ D_o$. The smaller body is 2.5 times as bright as the larger. Myers suspects increase of eccentricity and rotation of line of apsides between 1855 and 1892. Terkan estimates inclination at 51°. Curtiss finds 3 types of spectra, B8, B5, and *bright line*. †Elements from bright Hβ. (*P*, *e*, and ω assumed.) B5 lines give approximate constant velocity as does also the K line. *After principal minimum. $m_1 \sin^3 i=6.77\odot$; $m_2 \sin^3 i=16.64\odot$ Rossiter finds irregularity in velocity curve during principal minimum, with range of 26 km. due to rotational effect.
	− 0.8	Myers	*ApJ* **7**, 1, 1898	
	−20.95	Curtiss	*AO* **2**, 98, 1911	
	−13.0	Curtiss	*AO* **2**, 113, 1911	
	−19.02	Rossiter	Unpublished	
4788	− 8.79	Harper	*RASC* **13**, 236, 1919	Two spectra. Orbit of secondary. $m_1 \sin^3 i=0.95\odot$; $m_2 \sin^3 i=0.90\odot$
4790	−19.52	Young	*DAO* **1**, 265, 1920	
4794	−25.85	Jordan	*AO* **3**, 119, 1914	
4797	−23.2	Wilson	*LOB* **7**, 107, 1913	
4864	−18.65	Jordan	*AO* **3**, 82, 1914	*Time of maximum positive velocity.
4870	−21.19	Boothroyd	*DAO* **2**, 173, 1922	

TABLE III—Continued.

Boss	Star	R.A., 1900		Decl.		Mag.	Class	P.	T Jul. Day 2,410,000+	ω	e	K_1 km.	$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$	$a_1 \sin i$ 1,000 km.
....	RS Vul	19^h	13^m4	22°	16′	var	B8	4.477325	1.903*	236°26	0.053	54.98	....	3,388
												†175.9	....	10,842
....	U Sge		14.4	19	26	var	B9	3.380603	8428.183	44.14	0.035	66.45	0.1028	3,090
4934	υ Sgr		16.0	−16	9	4.58	B8p	137.937	9648.72	28.6	0.087	48.15	1.582	91,010
....	Z Vul		17.5	25	23	var	B3	2.45492	−0.014*	....	0.0	96.35	....	....
												213.74		
4947	2 Sge		19.8	16	45	6.03	A0	7.390	10943.233	332.6	0.05	52.95	0.11	5,370
												73.8	....	7,490
....	RR Lyr		22.3	42	36	var	F5	0.566826†	0.508*	96.853	0.271	22.2	0.00057	166
5018	σ Aql		34.3	5	10	5.17	B3	1.95022	10054.331	....	0.0	163.52	....	4,380
												199	....	5,340
5026	....		36.4	54	44	5.86	F5	7.6383	12201.398	46.74	0.527	89.81	....	8,017
										226.74	....	91.12	....	8,134
....	SU Cyg		40.8	29	1	var	F2p	3.845612	7425.06	108.0	0.31	14.0	0.00096	709
5070	....		47.2	40	21	5.62	B2	12.427	9636.226	120.08	0.199	94.40	1.02	15,808
5071	η Aql		47.4	0	45	var	G0p	7.176	6.210*	68.91	0.489	20.59	0.0043	1,773
5098	S Sge		51.5	16	22	var	G0p	*8.381589	9895.01	52.78	0.338	15.08	0.0025	1,635
								4.190795	9891.14	145.65	0.090	3.5	....	....
								682	10279.0	195.4	0.168	14.7	0.218	136,000
5099	φ Aql		51.5	11	9	5.29	A2	3.3204	13324.045	56.0	0.055	38.25	0.01923	1,745
5108	θ^1 Sgr		53.2	−35	33	4.39	B3	2.10514	1140.645	....	0.0	15.9	0.00088	460
5171	θ Aql	20	6.1	− 1	7	3.37	A0	17.1245	8261.914	14.9	0.681	46.0	....	7,930
										194.9	....	63.0	....	10,860
								17.1224	7731.377	26.98	0.691	49.50	....	8,424
5173	18 Vul		6.4	26	36	5.46	A2	9.316	10304.628	103.15	0.012	78.49	....	10,054
										283.15	....	86.31	....	11,055
5200	o^2 Cyg		12.4	47	24	4.16	K0	1170	10700.39	281.05	0.182	16.64	0.53	263,250
								*390	10515.821	....	....	5.86		
5216	β Cap		15.4	−15	6	3.25	G0	1375.3	6035	124.0	0.44	22.2	1.13	377,000
5223	α Pav		17.7	−57	3	2.12	B3	11.753	6379.90	224.80	0.01	7.25	0.00046	1,170
5292	ι Del		33.0	11	2	5.43	A2	10.9960	12095.816	60.81	0.252	26.72	0.020	3,910
....	X Cyg		39.5	35	14	var	G0p	16.38543	14.685*	101.1	0.246	28.03	0.034	6,121
5370	T Vul		47.2	27	53	var	F8p	4.43578*	3.76†	111	0.43	17.6	0.0018	969
								4.43578*	3.678†	104.03	0.440	17.63	0.0018	966
....	Y Cyg		48.1	34	17	var	B2	2.996332	....	....	0.0	223.9	....	19,220
												242.5		
5375	57 Cyg		49.7	44	0	4.68	B3	2.8546	8554.770	45	0.137	110.4	....	4,200
										225	....	118.8	....	4,620
....	HD 199579		53.1	44	33	6.01	Oe5	48.608	12892.226	66.75	0.0988	42.22	0.374	28,076
5442		21	4.4	29	48	5.57	A0	3.3137	12521.230*	....	0.0	26	0.0060	1,185
5460	τ Cyg		10.8	37	37	3.82	F0	0.1425	12522.641	263.0	0.306	8.0	0.000006	15
5469	σ Cyg		13.5	38	59	4.28	A0p	11.043	11069.27	119.1	0.40	1.98	0.0000007	276
....	HR 8170		17.2	39	55	6.46	F8	3.24343	11801.549	357.55	0.0223	62.23	0.0811	2,773

TABLE III—Continued.

Boss	V_o km.	Computer	Reference	Remarks
....	−22.04	Plaskett	*DAO* **1**, 143, 1919	Eclipsing variable. Mag. 7.4–8.1. *From minimum. Two spectra. †Orbit of fainter component. $(m_1+m_2) \sin^3 i=5.70\odot$; $m_2/m_1=0.31$. From Stewart's photometric orbit (darkened) and spectrographic elements ($i=68\overset{\circ}{.}41$), $r_1=2.05$ Sun's radius; $r_2=10.25$ Sun's radius; $m_1=5.40\odot$; $m_2=1.69\odot$; $d_1=0.63\,D_o$; $d_2=0.0016\,D_o$.
....	−19.13	Miss Fowler	*AO* **3**, 14, 1912	Algol variable.
4934	+12.1	Wilson	*LOB* **8**, 133, 1914	
....	−15.08	Plaskett	*DAO* **1**, 253, 1920	Eclipsing variable. Mag. 7.3–8.8. *From photometric phase. Two spectra; $m_2/m_1=0.45$. From Shapley's photometric orbit (darkened) and spectrographic elements $r_1=4.23$ Sun's radius; $r_2=4.46$ Sun's radius; $m_1=5.24\odot$; $m_2=2.36\odot$; $d_1=0.085\ D_o$; $d_2=0.033\ D_o$; a (separation of two stars) $=15.05$ Sun's radius.
4947	+11.0	Young	*DO* **4**, 66, 1917	Two spectra. Orbit of secondary. $m_1 \sin^3 i=0.91\odot$; $m_2 \sin^3 i=0.65\odot$
....	−68.7	Kiess	*LOB* **7**, 146, 1913	Cluster variable. Type varies B9–F2, Shapley, *ApJ* **44**, 274, 1916. *Interval after visual maximum. †Light period.
5018	− 5.00	Jordan	*AO* **3**, 192, 1915	Two spectra. $m_1 \sin^3 i=5.3\odot$; $m_2 \sin^3 i=4.4\odot$. K line has constant velocity. Orbit of secondary.
5026	−15.59	Harper	*DAO* **1**, 161, 1919	Two spectra. Orbit of secondary. $m_1 \sin^3 i= 1.854\odot$; $m_2 \sin^3 i=1.827\odot$
....	var*	Hellerich	*AN* **210**, 68, 1919	Cepheid variable. Orbit from Lick plates. $^*V_o=-35.8+.47$ $(t-2417425.00)$ km. Spectrum varies A6 to F7, Shapley.
5070	− 6.18	Harper	*DAO* **1**, 261, 1920	
5071	−14.16	Wright	*ApJ* **9**, 66, 1899	Cepheid variable. Spectrum varies A8–G5, Shapley. *Interval after maximum brightness. Orbit by Belopolsky, *ApJ* **6**, 399, 1897.
5098	var var − 3	Aldrich	Unpublished	Cepheid variable. Elements improved over those in *PA* **32**, 218, 1924. *Short period irregular variation synchronous with light curve and resembling it in form, but *different* for *different* lines. Earlier orbit by Hellerich from Lick plates of 1906, *AN* **210**, 67, 1919. Spectrum varies F4 to G3, Shapley.
5099	−27.63	Harper	*DAO* **2**, 182, 1922	
5108	+ 0.9	Wilson, Huffer	*PA* **29**, 86, 1921	
5171	−30.5	Baker	*AO* **2**, 43, 1910	Two spectra. Orbit of secondary. $m_1 \sin^3 i=0.52\odot$; $m_2 \sin^3 i=0.38\odot$; $m_2/m_1=0.73$. Harper finds $m_2/m_1=0.75$.
	−25.93	Harper	*RASC* **6**, 269, 1912	
5173	−13.04	Harper	*DO* **4**, 219, 1918	Two spectra. Orbit of secondary. $m_1 \sin^3 i=2.27\odot$; $m_2 \sin^3 i=2.06\odot$.
5200	−14.35	Cannon	*DO* **4**, 172, 1918	*Residuals from elliptic motion represented by sine curve of 1/3 the period of principal curve.
5216	−18.8	Merrell	*LOB* **6**, 6, 1910	
5223	+ 2.0	Curtis	*LOB* **4**, 154, 1907	
5292	− 5.50	Harper	*DAO* **1**, 156, 1919	
....	+ 9.32	Duncan	*ApJ* **53**, 95, 1921	Cepheid variable. Mag. 6.2–7.4. *Interval after light maximum.
5370	− 1.3	Albrecht	*LOB* **4**, 135, 1907	Cepheid variable. Spectrum varies A9–G1, Shapley. *Light period. †After light maximum. Least square reduction of Albrecht's observations. Velocity curve may be variable.
	− 1.39	Beal	*AO* **3**, 198, 1915	
....	−49.1	Plaskett	*DAO* **1**, 215, 1920	Eclipsing variable. Mag. 7.1–7.9. Two spectra. H and K stationary. $(m_1+m_2) \sin^3 i=31.57\odot$; $m_2/m_1=0.92$. From Shapley's (darkened) photometric orbit and spectroscopic data, $m_1=16.6\odot$; $m_2=15.3\odot$; $d_1=0.170\ D_o$; $d_2=0.158\ D_o$; $r_1=r_2=3{,}216{,}000$ km.; $a=19{,}294{,}000$ km.
5375	−16.2	Baker	*AO* **2**, 38, 1910	Two spectra. Orbit of secondary. $m_1 \sin^3 i=1.79\odot$; $m_2 \sin^3 i=1.67\odot$
....	− 5.78	Plaskett	*DAO* **2**, 186, 1922	Velocity Ca lines = −11.3 km.
5442	−26.8	Young	*DAO* **1**, 321, 1921	Approximate elements. *Perihelion.
5460	−22.0	Paraskévopoulos	*ApJ* **53**, 146, 1921	Brighter component of visual pair.
5469	− 3.80	Henroteau	*Det O* **3**, 49, 1917	Earlier Lick observations are represented on his curve with a period $=11\overset{d}{.}055$.
....	+ 0.16	Plaskett	*DAO* **1**, 115, 1919	

TABLE III—Concluded.

Boss	Star	R.A., 1900		Decl.		Mag.	Class	P.	T Jul. Day 2,410,000 ÷	ω	e	K_1 km.	$\frac{m_2^3 \sin^3 i}{(m_1 \div m_2)^2}$	$a_1 \sin i$ 1,000 km.
5532	β Cep	21^h	27^m4	70°	7′	3.32	B1	0.190479	7398.859	165°2	0.03+	16.9	0.000095	....
								0.1904795	9638.8119	2.63	0.040	15.80	....	40.5
								*0.1904795	9638.8204	16.53	0.052	19.22		
5565			35.8	57	2	5.64	Oe5	1.36372	13300.551	289.94	0.334	77.01	0.054	1,354
5566	42 Cap		36.1	−14	30	5.28	G5	*13.25	11529.16	175	0.20	22.75	0.01640	4,061
								†13.16582	11529.16	157	0.24	24.5	....	4,306
5591			39.9	28	19	6.90	A5	3.74860	12175.1577	262.66	0.189	92.1	....	4,662
										82.66	....	93.2	....	4,728
5592	κ Peg		40.1	25	11	4.27	F5	*5.9715	5239.25	4.7	0.04	39.81	0.443	3,266
								†5.9715	9593.17	47.5	0.03	40.35	....	3,312
								††5.9715	11440.69	189.4	0.034	41.53	....	3,408
5600	δ Cap		41.5	−16	35	2.98	A5	1.02275	11451.86	149.057	0.019	65.67	0.03007	926
....	H.R.8427	22	2.0	47	45	6.16	B3	2.1721	12138.172*	....	0.0†	127.7	0.47	3,810
5688	ι Peg		2.4	24.51		3.96	F5	10.21312	4820.966	251.81	0.008	47.99	0.117	6,740
5764	2 Lac		16.9	46	2	4.66	B5	2.6164	8193.30	180	0.015	80.3	....	2,890
										0	....	98.8	....	3,550
5805	δ Cep		25.4	57	54	var	G0	5.367	*1.002	82.81	0.355	19.81	0.0037	1,371
								5.366404†	7888.428	85.38	0.484	19.68	0.0028	1,271
5856	12 Lac		37.0	39	42	5.18	B2	0.193089	*10761.1488	....	0.0	16.92	0.0001	45,000
5865	η Peg		38.3	29	42	3.10	G0	818.0	5288.7	5.60	0.155	14.20	0.234	157,800
5900			48.1	16	19	5.72	K0	24.65	12240.992	....	0	33.20	0.094	11,254
....	H.R.8800	23	2.7	45	33	6.56	B5	3.3372	12151.272	125.67	0.233	87.70	0.215	3,910
....	H.R.8803		3.0	59	13	6.28	B3	7.25050	11825.038	71.58	0.376	90.54	0.3464	7,751
5965	ι Gru		4.7	−45	47	4.10	K0	409.444	16116.137	251	0.75	15.44	0.04530	57,500
5996	9 And		13.6	41	14	5.90	A3	3.2195	11059.912	40.57	0.036	73.56	0.133	3,240
6046	1 Cas		25.4	58	0	4.89	B3	6.067	8223.762	3.35	0.224	59.06	0.1203	4,920
6071	λ And		32.7	45	55	4.00	K0	20.538	4571.81	336.2	0.132	6.48	0.0006	1,810
								20.546	6683.46	301.0	0.086	7.07	0.0007	1,990
....	Lal 46867		50.0	28	5	7.30	K0	6.72127	12220.7403	18.6	0.059	38.5	0.0125	3,552
6142			50.5	56	51	6.05	B0	13.435	10800.634	339.56	0.105	115.5	2.11	21,200
												167*		30,700
6148			52.1	55	9	5.69	F5	12.155	12162.601	213.45	0.278	71.52	....	11,483
										33.45	....	72.97	....	11,716

TABLE III—Concluded.

Boss	V_0 km.	Computer	Reference	Remarks
5532	− 4.9	Frost	*DetO* **2**, 145, 1915	Cepheid variable. Frost's elements are from observations of one night. *Elements from observations of one night, Oct. 1, 1912.
	−14.13	Crump	*DetO* **2**, 152, 1915	
	−12.88	Crump	*DetO* **2**, 153, 1915	Residuals from elliptic curve represented by secondary curve of ⅓ the major period and semi-amplitude 1.25 km. There is some evidence of a variation in the velocity of center of mass and in the amplitude of the velocity curve.
5565	− 1.04	Plaskett	*DAO* **2**, 273, 1923	
5566	− 4.4	Lunt	*CA* **10**, 3F, 1921	*Elements for 1917 (corrected), *ApJ* **47**, 134, 1918. †Elements for 1920 observations. Lunt finds indications of a rotation of the line of apsides.
	− 1.5	Lunt	*CA* **10**, 3F, 1921	
5591	+ 4.2	Sanford	*ApJ* **53**, 219, 1921	Two spectra.
				Orbit of secondary. $m_1 \sin^3 i = 1.19\odot$; $m_2 \sin^3 i = 1.17\odot$
5592	− 2.80	Henroteau	*LOB* **9**, 122, 1918	Visual double with period 11.35 years. Not known which component is spectroscopic binary. The spectrum of other star is visible on some of the spectrograms. From elements of visual orbit by Lewis and the spectroscopic data, Henroteau finds $(m_1+m_2)=10.33\odot$; M_1 (mass of other visual component) $=4.00\odot$, $m_1 \sin i = 3.62\odot$ Assuming that the planes of the two orbits (visual and spectroscopic) coincide, $m_1=6.62\odot$; $m_2=3.71\odot$ Henroteau obtains evidence of rotation of line of apsides of spectroscopic binary orbit in period of visual pair. He finds $\pi = 0''.025 \pm 0''.002$.
	− 3.79	Henroteau	*LOB* **9**, 122, 1918	
	−14.62	Henroteau	*LOB* **9**, 122, 1918	
5600	− 5.82	Crump	*ApJ* **54**, 131, 1921	
....	−17.76	Young	*DAO* **1**, 195, 1920	*Perihelion passage. †Assumed. H and K lines of calcium yield a constant velocity of +1.5 km.
5688	− 4.12	Curtis	*LOB* **2**, 172, 1904	Zurhellen from Bonn observations obtains $V_0 = -3.81$ km. and other elements closely approximating those of Curtis *AN* **177**, 333, 1908.
5764	− 9.0	Baker	*AO* **1**, 98, 1909	Two spectra.
				Orbit of secondary. $m_1 \sin^3 i = 0.87\odot$; $m_2 \sin^3 i = 0.71\odot$
5805	var	Belopolsky	*Mitt. Pulk.* **3**, 69, 1909	Cepheid variable (prototype). Earlier orbit by Belopolsky, *ApJ* **1** 160, 1895. He finds velocity of system variable with a period of 6.36 years. Moore's observations do not support this conclusion. *Interval after light minimum. †Photometric period. Spectrum varies F0–G2, Shapley.
	−16.83	Moore	*LOB* **7**, 154, 1913	
5856	−13.75	Young	*DO* **3**, 88, 1915	*Perihelion. Young *DAO* **1**, 105, 1918, finds amplitude of velocity curve varies from night to night with a range from 0 to 70 km. The shape of the curve is not constant and spectral lines vary in width. Velocity of system subject to long period variation. Amplitude from calcium lines show same variation as that from other lines. See also *PA* **30**, 20, 1922.
5865	+ 4.31	Crawford	*LOB* **1**, 29, 1901	
5900	−12.84	Harper	*DAO* **1**, 205, 1920	
....	−15.13	Young	*DAO* **1**, 243, 1920	Velocity calcium = −9.1 km.; constant H and K.
....	− 7.45	Boothroyd	*DAO* **1**, 284, 1921	K line stationary. On a few plates two components of K line are visible, one on each side of stationary line. The faint second spectrum was measured on some of spectrograms. The mass of secondary is estimated to be 0.8 that of primary.
5965	− 3.57	Lunt	*CA* **10**, 12G, 1924	
5996	− 4.87	Young	*DO* **4**, 92, 1917	
6046	−14.78	Baker	*AO* **2**, 28, 1910	
6071	+ 6.34	Burns	*LOB* **4**, 89, 1906	Old series.
	+ 7.43	Burns	*LOB* **4**, 89, 1906	New series.
....	−19.8	Sanford	*ApJ* **53**, 221, 1921	Bright H and K superimposed upon usual broad absorption lines yield same velocities as other absorption lines.
6142	−26.7	Young	*DO* **3**, 387, 1916	H and K lines stationary. *From measures of secondary spectrum on 7 plates. $m_1 \sin^3 i = 18.5\odot$; $m_2 \sin^3 i = 12.7\odot$
6148	+11.98	Harper	*DAO* **2**, 267, 1923	Two spectra.
				Orbit of secondary. $m_1 \sin^3 i = 1.704\odot$; $m_2 \sin^3 i = 1.671\odot$

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ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 356

ELEMENTS AND EPHEMERIS OF COMET c 1924 (FINSLER)

The following observations were available for the determination of the orbit of this comet:

	1924 Gr.M.T.	α (1924.0)	δ (1924.0)	Observer
1	Sept. 21.6367	$14^h\ 09^m\ 29^s.80$	$+8°\ 23'\ 43''.5$	Jeffers, Lick
2	23.5233	14 21 10.6	+5 39 09	Bower, Washington
3	23.5396	14 21 16.3	+5 37 47	Van Biesbroeck, Yerkes
4	23.6599	14 21 57.85	+5 27 45.1	Jeffers
5	24.5104	14 26 41.2	+4 18 17	Bower
6	24.6485	14 27 25.65	+4 07 15.6	Jeffers
7	26.6485	14 37 24.86	+1 35 08.3	Jeffers
8	28.6548	14 46 13.88	−0 43 45.9	Jeffers
9	30.6422	14 53 58.83	−2 48 51.9	Jeffers

An orbit was originally based upon the first, fourth, and sixth observations, but owing to an error in the computation its completion was delayed. The observation of September 26 having become available in the meantime, it was substituted for that of September 24 and the orbit completed. This orbit, which is given below, required no further correction when the arc was extended to September 30 as last date, with September 26 as middle date. The elements are as follows:

ELEMENTS

T = 1924, Sept. 4.33014 Gr. M. T.

$$\left.\begin{aligned} \omega &= 66°\ 32'\ 40''.2 \\ \Omega &= 80\ \ 05\ \ 43.2 \\ i &= 120\ \ 03\ \ 00.0 \end{aligned}\right\}\ 1924.0$$

$\log q = 9.608538$

RESIDUALS

(O—C)	Sept. 21	Sept. 30
$\cos\delta\,\Delta\alpha$	0″	−1″
$\Delta\delta$	0	+5

CONSTANTS FOR THE EQUATOR 1924.0

$$x = r\,[9.718019]\sin(85°\ 46'\ 05''.4 + v)$$
$$y = r\,[9.999146]\sin(181\ \ 39\ \ 03.9 + v)$$
$$z = r\,[9.931961]\sin(93\ \ 50\ \ 03.0 + v)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT

1924	α (true)	δ (true)	$\log\Delta$	Br.
Oct. 2.5	$15^h\ 00^m\ 33^s$	$-4°\ 36'.2$	0.132	0.56
6.5	15 12 45	− 7 58.1	.169	.40
10.5	15 23 05	−10 48.2	.204	.29
14.5	15 32 04	−13 13.6	.235	.22

The unit of brightness is that of September 26.

The foregoing results agree closely with the elements derived by Van Biesbroeck and Comrie from observations of September 21, 23, and 25.

The earlier part of the work was done in duplicate by Miss L. Allen and the latter part by Dr. H. Thiele.

A. D. MAXWELL.

Berkeley Astronomical Department
October 2, 1924

Issued October 6, 1924.

UNIVERSITY OF CALIFORNIA PUBLICATIONS

ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 357

PRELIMINARY ELEMENTS AND EPHEMERIS OF OBJECT BAADE

The following observations have been received at the Students' Observatory:

	1924 Gr.M.T.	α(1924.0)	δ(1924.0)	Observer
1	Oct. 23.3094	$21^h05^m14^s$	+15°27′.6	Baade, Bergedorf
2	25.3743	21 15 29.0	+14 06 45″	Delporte, Brussels
3	26.6883	21 21 43.40	+13 14 14.0	Van Biesbroeck, Yerkes
4	27.5066	21 25 43.95	+12 42 33.2	Van Biesbroeck
5	28.6239	21 31 10.20	+11 58 54.5	Van Biesbroeck
6	29.5808	21 35 49.20	+11 21 51.0	Bower, Washington
7	30.7364	21 41 24.70	+10 37 31.5	Jeffers, Lick
8	31.5104	21 45 09.10	+10 08 10.0	Bower
9	31.6576	21 45 51.51	+10 02 35.4	Jeffers
10	Nov. 3.6349	22 00 03.19	+ 8 12 56.8	Tucker, Lick
11	3.6649	22 00 11.63	+ 8 11 54.7	Jeffers
12	10.7943	22 32 53.22	+ 4 14 43.7	Jeffers

Announcement of the discovery of the object with the approximate position (1) and the position (2) were received by telegraph from the Harvard College Observatory. Observations (3) to (6) and (8) were received from the Yerkes and the United States Naval Observatories in answer to a request telegraphed on October 30. Micrometer and meridian circle observations (7) and (9) to (12) were received by telephone from the Lick Observatory.

The orbit computation was originally based on observations (3), (5), and (7) of October 26, 28, and 30. Subsequent observations became available in the course of the computation.

As the rapid motion of the object suggested fairly close proximity to the earth, a complete elimination of the parallax, including the barycentric parallax on account of the position of the moon, in accordance with the formulae given in *Publ. L. O.*, Vol. 7, page 233 and following, was undertaken in order to increase the accuracy of the solution. This precaution was essential on account of the fairly uniform motion of the object which yielded only two significant figures for the accelerations. The first approximation of the geocentric distance, $\rho = 0.868$ interpolated from the tables, *Publ. L O.*, Vol. VII, page 345 corresponded to a distinctly hyperbolic orbit and was abandoned for an investigation of the possibility of a considerably smaller geocentric distance. While no definite geocentric distance corresponding to the given values of ψ and 1/m was found in the tables, as is often the case when 1/m cannot be accurately determined from the observations, a value of $\rho = 0.05$ was assumed as probable within the range of solution. Satisfactory representations of subsequent observations were obtained on the assumption of various small geocentric distances, but the existing range of solution together with the large variation in the parallaxes corresponding to small geocentric distances rendered it inadvisable further to pursue the investigation of the reality of a very small geocentric distance on the basis of the short arc. In the mean time, to test the possibility of a geocentric distance in the neighborhood of that given by the tables a parabolic solution had also been completed with the following residuals resulting from the direct solution:

O—C	Δα	Δδ
October 26	−17″.8	+2″.7
October 30	− 7.4	−8.5

Additional observations having become available, all observations to November 3 were compared with the parabolic orbit in order to detect possible errors of observation. This comparison suggested that the declination of October 26 was sufficiently in error to destroy the validity of all previous results. The parabola, however, was retained as a first approximation for a new orbit determination based on observations (4), (7), and (11) of October 27, October 30, and November 3. As constants for the intermediate orbit the observed α and δ of October 30, the geocentric distance, ρ, and the heliocentric velocities x', y', and z', corresponding to the parabolic orbit for the same date were chosen in the usual way. With these six constants, the newly adopted first and third places were computed with the following results:

O—C	Δα	Δδ
October 27	− 6″.6	+50″.2
November 3	−67.2	+20.5

Two differential corrections, the second on the basis of the approximate formulae, *Publ. L. O.*, Vol. VII, page 266, gave the following results:

ELEMENTS

Epoch	1924, Oct. 30.73337 Gr.M.T.			
M_0	6°	59′	33″.6	
ω	130	49	48.0	1924.0
☊	216	17	23.7	
i	26	18	45.8	
ϕ	33	20	51.3	
log e	9.740139			
a	2.73481			
μ	784″.530			
P	4.523 years			

CONSTANTS FOR THE EQUATOR 1924.0

$$x=r(9.984515)\sin(74^\circ\ 11'\ 2''.6+v)$$
$$y=r(9.999818)\sin(343\ \ 44\ \ 0.1+v)$$
$$z=r(9.421517)\sin(67\ \ 39\ \ 50.4+v)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT

1924		True α			True δ			log Δ	mag.
Nov.	12.5	22ʰ	40ᵐ	27ˢ.0	+3°	24′	35″	9.774	9.3
	14.5	22	49	04.2	2	28	44		
	16.5	22	57	29.4	1	36	35	9.796	9.5
	18.5	23	05	42.5	0	48	10		
	20.5	23	13	43.6	+0	03	24	9.818	9.6
	22.5	23	21	32.6	−0	37	42		
	24.5	23	29	09.8	1	15	10	9.842	9.8
	26.5	23	36	35.5	1	49	12		
	28.5	23	43	49.5	2	19	55	9.867	9.9
Nov.	30.5	23	50	52.8	2	47	22		
Dec.	02.5	23	57	45.1	3	11	45	9.892	10.1
	04.5	0	04	27.0	3	33	15		
	06.5	0	10	59.0	3	52	01	9.917	10.2
	08.5	0	17	21.2	4	08	10		
	10.5	0	23	34.2	4	21	54	9.942	10.4
	12.5	0	29	38.7	4	33	06		
Dec.	14.5	0	35	33.8	−4	42	40	9.966	10.6

The magnitude on October 30 was assumed to be 9.0.

Opposition occurred on June 24 at a geocentric distance of 0.785 astronomical units. The closest approach to the earth was early in September at a distance of a little over a third of an astronomical unit.

RESIDUALS, O—C

	Gr.M.T.		Δα	Δδ
(1)	Oct.	23.31	+0′.2	−0′.8
(2)		25.37	[+2′ 42″.2]	[+8″.4]
(3)		26.69	+2.5	[−28.6]
*(4)		27.51	0.0	0.0
(5)		28.62	+0.3	+0.2
(6)		29.58	−0.7	+1.2
*(7)		30.74	0.0	0.0
(8)		31.51	+0.3	−0.7
(9)	Oct.	31.66	+1.2	−2.4
(10)	Nov.	3.63	−1.4	−1.4
*(11)		3.66	−1.4	+1.9
(12)	Nov.	10.79	−1.4	+2.2

The orbit and ephemeris are based on the starred positions (4), (7), and (11).

The subsequent observation (12) of November 10 by Jeffers is well represented. All of the accepted observations are nearly represented within the accuracy attainable in this case with a six-place computation.

The suspected error in the declination of October 26 is fully substantiated. The solution could have been accomplished with little difficulty if all three observations which originally formed the basis of the orbit computation had been correct. The observations of October 23 and 25 were rejected at the start, the former because only an approximate position was given, the latter because the right ascension was readily seen to be in error.

The effects of the error in the declination of October 26 and of completely eliminating the parallax may be seen by inspection of the average velocities in α and δ between the first and second, and second and third dates derived from a properly corrected value of the first declination.

AVERAGE VELOCITIES PER MEAN SOLAR DAY

	α	diff.	δ	diff.	δ	
Oct. 26–28	+4395″	−31″	−2350″	+39″	(−2335)	(+24″)
Oct. 28–30	+4364		−2311		−2311	

The accelerations which enter into the argument 1/m for the interpolation of the geocentric distance are derived from the differences −31″ and +39″ of the average velocities in α and δ. The numbers in parenthesis represent the average velocity in declination, etc., derived from the erroneous value of October 26. For the determination of the accelerations in α and δ disregarding other errors of observation only two significant figures are available. The error in the first declination thus completely vitiated the value of the acceleration in δ.

With observations accurate to the nearest second of arc the geocentric arc from October 26 to 30 should have given the geocentric distance correct to two significant figures. Recomputation by Dr. Thiele of

1/m and 1/(m) with the corrected declination of October 26 gave with the aid of the tables as a first approximation of the geocentric distance at the middle date, October 28, $\rho=0.512$. The corresponding value computed from the adopted orbit based on the longer geocentric arc, October 27 to November 3, is $\rho=0.518$. Thus the theoretically predicted accuracy of the solution from the short arc is fully confirmed.

The corrections for parallax of the three originally used observations on the basis of the resulting orbit are:

	p^g_α	p^m_α	p_α	p^g_δ	p^m_δ	p_δ
Oct. 26	+10″.5	+10″.9	+21″.4	+9″.5	−8″.1	+ 1″.4
28	+ 6.5	+12.3	+18.8	+8.9	+2.2	+11.1
30	+ 8.2	+10.9	+19.1	+8.0	+4.6	+12.6

where p^g, p^m, and p represent the geocentric, barycentric, and general parallaxes, respectively. Corrected for these parallaxes, the observations give the following average velocities with their differences:

Average Velocities per Mean Solar Day

	α	difference	δ	difference
Oct. 26–28	+4394″	−30″	−2345″	+35″
28–30	+4364		−2310	

The complete elimination of the parallax by proper correction of the solar coördinates produces the same effect on the resulting orbit as if the observations had been corrected for parallax in advance.

While the parallax elimination tended slightly to increase the accuracy of the orbit, the error in the first declination more than offset this advantage, which accounts for the discordance of the value of the geocentric distance 0.868, interpolated from the table, from the true value 0.512, and also introduced the possibility of an additional but indefinite solution corresponding to a very small geocentric distance. These uncertainties were partially removed by the conditioned solution for a parabola referred to above which finally lead to the selection of the observations (4), (7), and (11), October 27 and 30, and November 3 for the determination of the orbit and to its satisfactory solution.

From a comparison made by Dr. Thiele with the elements of planets Nos. 1 to 995 it appears that the eccentricity of the orbit is exceeded only by that of planet (944) Hidalgo with $\varphi=40°.8$. The planets (719) Albert with $\varphi=32°.7$ and (887) Alinda with $\varphi=32°.2$ have nearly as large eccentricities. The inclination is exceeded by about a dozen planets of which (944) has the greatest, $i=43°.1$. The planet is the fourth in the order of possible closest approach to the earth in opposition at perihelion with $q=1.232$. The corresponding perihelion distances for the other three are: (433) Eros, $q=1.133$; (887) Alinda, $q=1.182$, and (719) Albert, $q=1.190$. There is, however, no planet of both as high an eccentricity and inclination, which can come as close to the earth as this new planet.

The elements, of course, will receive some modification with a longer arc.

The computation of the orbit was undertaken under my direction by Dr. H. Thiele, Research Associate in Astronomy, with the assistance of graduate students who undertook to duplicate the work in connection with their studies in theoretical astronomy. The preliminary stages of the computation up to the interpolation of the geocentric distance $\rho=.868$ were carried out by Dr. H. Thiele and duplicated by Misses L. B. Allen and K. Prescott, and Mr. T. S. Jacobsen. When this hyperbolic solution was abandoned Dr. Thiele and Mr. A. D. Maxwell investigated the possibility of a solution corresponding to a very small geocentric distance while Mr. Jacobsen and Miss Allen performed the parabolic solution. Mr. Maxwell also carried out a preliminary solution with the elimination of the parallax by taking into account the perturbations of the earth in the first approximation. This also led to a very small geocentric distance, being based on the erroneous declination of October 26. The comparison of all the observations available to November 3 with the parabolic orbit was distributed among the various computers so that every residual was checked. After the declination of October 26 had been eliminated by a comparison of these residuals, Mr. Maxwell, Miss Allen and Mr. Jacobsen computed the constants for the intermediate orbit based on October 30 as new middle date as well as the residuals for October 27 and November 3, and performed the first differential correction of the orbit. The second differential correction was carried out by Messrs. Thiele and Maxwell with the use of the approximate formula referred to above. The date of opposition and the predicted magnitudes were computed by Mr. Maxwell. The residuals corresponding to the adopted orbit were computed directly from the elements and constants for the equator by Messrs. Thiele and Maxwell for October 23, 25, 27, 30, both places of November 3, and for November 10 and by Miss Allen and Mr. Jacobsen for October 26, 28, 29, 31, and the second of November 3.

It has been deemed worth while to give a full account of the work as an illustration of the effect of a serious error of observation in the case of fairly uniform motion, and of the elimination of the parallax in the case of comparatively close approach to the earth.

A. O. Leuschner.

Berkeley Astronomical Department,
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ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 358

ELEMENTS AND OPPOSITION EPHEMERIS OF MINOR PLANET Y. O. 11.

Minor planet Y. O. 11 was discovered at the Yerkes Observatory 1923, November 11, by G. Van Biesbroeck on a plate taken for (926) which was missing. The brighter asteroid *Themis* appeared on all plates from 1923, November 11, to 1924, March 5. The observations, which were mailed to the Berkeley Astronomical Department and later published in the *Astronomical Journal*, **36**, 841-842, are as follows:

	1923	α	1923.0		δ			mag.
(1)	Nov. 11.77662	3^h	23^m	$01^s.91$	+19°	17′	50″.0	14.7
(2)	Nov. 17.87084	3	17	51.57	+19	0	35.3	14.8
(3)	Dec. 13.71630	2	59	04.41	+17	51	05.9	14.9
	1924		1924.0					
(4)	Jan. 4.72360	2^h	52^m	$49^s.67$	+17°	25′	49″.9	15.4
(5)	Jan. 25.62673	2	57	09.41	+17	44	08.9	
(6)	Mar. 5.55528	3	28	34.55	+19	45	17.1	16.5
	Mar. 5.57798	3	28	35.72	+19	45	24.8	16.5

The positions of December 13 and January 25, given above, differ from those published in the *Astronomical Journal* by corrections reported later by Van Biesbroeck.

It has been found impossible to represent all of the observations precisely by one and the same orbit. The elements given below represent five observations with considerable accuracy:

ELEMENTS

Epoch	1924, Jan. 4.70927 Gr.M.T.	
M	282° 48′ 38″	
ω	123 18 58	1925.0
☊	29 58 13	
i	1 18 07	
e	0.128342	
μ	631″.42	
P	5.6194 years	
log a	0.499793	

CONSTANTS FOR THE EQUATOR 1925.0

$$x = r[9.999972] \sin (243° \; 16' \; 48''.2 + v)$$
$$y = r[9.958762] \sin (153 \; 34 \; 38.8 + v)$$
$$z = r[9.619136] \sin (151 \; 51 \; 30.5 + v)$$

The residuals were concentrated, as far as possible, in the first right ascension, and are as follows:

O—C	$\Delta\alpha \cos\delta$	$\Delta\delta$
(1)	+15″.0	−1″.0
(2)	− 4.2	−0.8
(3)	− 3.8	+0.7
(4)	+ 2.1	+0.6
(5)	− 2.8	−0.5
(6)	− 1.5	−2.3

EPHEMERIS FOR GREENWICH CIVIL MIDNIGHT

	True α			True δ		log Δ	mag.
1925, Jan. 2.0	10^h	16^m	43^s	+12°	31′.3	0.309	14.7
Jan. 10.0	10	15	34	+12	41.3		
Jan. 18.0	10	12	51	+12	59.1	0.276	14.6
Jan. 26.0	10	08	42	+13	24.0		
Feb. 3.0	10	03	21	+13	54.0	0.254	14.5
Feb. 11.0	9	57	12	+14	26.5		
Feb. 19.0	9	50	44	+14	58.7	0.248	14.4
Feb. 27.0	9	44	27	+15	28.0		
Mar. 7.0	9	38	52	+15	51.9	0.260	14.5
Mar. 15.0	9	34	24	+16	09.0		
Mar. 23.0	9	31	19	+16	18.5	0.286	14.6
Mar. 31.0	9	29	48	+16	20.1		

The first and last places of the ephemeris were also computed from an orbit giving the following residuals:

O—C	$\Delta\alpha \cos\delta$	$\Delta\delta$
(1)	+ 0″.4	−4″.3
(2)	−12.6	−2.7
(3)	+ 0.6	+2.0
(4)	+ 0.9	−0.1
(5)	−10.8	−3.0
(6)	+ 0.3	−1.9

This orbit would require the following corrections to the ephemeris:

	$\Delta\alpha$	$\Delta\delta$
1925, Jan. 2.0	$-2^m \; 06^s$	+10′.6
Mar. 31.0	−2 24	+11.8

I am pleased to acknowledge the assistance of Mr. T. S. Jacobsen in checking the earlier part of the computation.

A. D. MAXWELL

BERKELEY ASTRONOMICAL DEPARTMENT,
November 30, 1924.

EPHEMERIS OF COMET c 1924 (FINSLER)

The elements of Comet c 1924, published in *Lick Obs. Bull.*, **9**, 356, represent an observation on 1924, Oct. 7, by Jeffers, as follows:

	O—C
$\Delta\alpha \cos\delta$	−0′.2
$\Delta\delta$	+0.4

This orbit therefore appears sufficiently accurate for extending the ephemeris to facilitate observation of the comet after it shall have become a morning object in December.

Ephemeris for Greenwich Mean Midnight

1924	True α	True δ	log Δ	Br.
Dec. 1.5	16ʰ 42ᵐ 11ˢ	−28° 24′.4	0.452	0.024
3.5	16 44 28	−28 47.7		
5.5	16 46 43	−29 10.5	0.461	.022
7.5	16 48 55	−29 32.9		
9.5	16 51 06	−29 54.8	0.470	.020
11.5	16 53 15	−30 16.3		
13.5	16 55 23	−30 37.5	0.478	.019
15.5	16 57 28	−30 58.3		
17.5	16 59 31	−31 18.8	0.485	.017
19.5	17 01 33	−31 39.1		
21.5	17 03 33	−31 59.1	0.491	.016
23.5	17 05 30	−32 18.9		
25.5	17 07 26	−32 38.5	0.497	.014
27.5	17 09 19	−32 58.0		
29.5	17 11 10	−33 17.3	0.502	.013

Ephemeris for Greenwich Civil Midnight

1925	True α	True δ	log Δ	Br.
Jan. 1.0	17ʰ 12ᵐ 59ˢ	−33° 36′.5		
3.0	17 14 46	−33 55.6	0.506	.012
5.0	17 16 30	−34 14.5		
7.0	17 18 12	−34 33.5	0.509	.012
9.0	17 19 51	−34 52.3		
11.0	17 21 28	−35 11.2	0.512	.011
13.0	17 23 02	−35 30.0		
15.0	17 24 33	−35 48.9	0.514	.010
17.0	17 26 01	−36 07.8		
19.0	17 27 27	−36 26.7	0.516	.010
21.0	17 28 49	−36 45.7		
23.0	17 30 08	−37 04.8	0.517	.009
25.0	17 31 23	−37 23.9		
27.0	17 32 35	−37 43.2	0.518	.009
29.0	17 33 44	−38 02.5		
31.0	17 34 48	−38 22.0	0.518	.008

The unit of brightness is that of September 26.

A. D. Maxwell

Berkeley Astronomical Department,
November 30, 1924.
Issued December 6, 1924.

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